BRENT WILEY, *Editor*
T. J. ESS, *Associate Editor*
JAMES D. KELLY, *Advertising Manager*

BOARD OF DIRECTORS

PRESIDENT
WILLIAM A. PERRY
Superintendent Electrical and Power Departments
Inland Steel Company
Indiana Harbor, Indiana

1ST VICE-PRESIDENT, THOMAS E. HUGHES, *Superintendent of Maintenance*, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania

2ND VICE-PRESIDENT, FRANK E. FLYNN, *District Manager*, Republic Steel Corporation, Warren, Ohio

TREASURER, C. L. McGRANAHAN, *Assistant General Superintendent*, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania

SECRETARY, J. L. MILLER, *Assistant Chief Combustion Engineer*, Republic Steel Corporation, Cleveland, Ohio

PAST PRESIDENTS: JULIUS A. CLAUSS, *Chief Engineer*, Great Lakes Steel Corporation, Ecorse, Michigan

C. CLARKE WALES, *Vice-President*, Hamilton Bridge Company, Ltd., Hamilton, Ontario, Canada

HONORARY DIRECTORS: JAMES FARRINGTON, *Electrical Superintendent*, Wheeling Steel Corporation, Steubenville, Ohio

A. C. CUMMINS, *General Superintendent*, Youngstown District, Carnegie-Illinois Steel Corporation, Youngstown, Ohio

WALTER H. BURR, *Electrical Superintendent*, Lukens Steel Company, Coatesville, Pennsylvania

DIRECTOR-AT-LARGE, P. F. KINYOUN, *Combustion Engineer*, Bethlehem Steel Company, Lackawanna, New York

DIRECTORS: FREEMAN H. DYKE, *Superintendent Blooming, Bar, and Hot Strip Mills*, Wheeling Steel Corporation, Steubenville, Ohio

A. R. DIBBEN, *Assistant Electrical Superintendent* Youngstown Sheet and Tube Company, East Chicago, Indiana

GEORGE C. PFEFFER, *Superintendent of Power*, Florence Pipe Foundry and Machine Company, Florence, New Jersey

W. J. WILSON, *Chief Electrician*, American Cast Iron Pipe Company, Birmingham, Alabama

L. N. TULL, *Electrical Superintendent*, Republic Steel Corporation, Cleveland, Ohio

STEPHEN M. JENKS, *General Superintendent*, Gary Works, Carnegie-Illinois Steel Corporation, Gary, Indiana

E. J. GOULD, *Assistant Chief Engineer of Construction*, Bethlehem Steel Company, Bethlehem, Pennsylvania

R. S. SHOEMAKER, *Lubrication Engineer*, American Rolling Mill Company, Middletown, Ohio

C. H. WILLIAMS, *Assistant Chief Engineer*, Pittsburgh District, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania

Managing Director
BRENT WILEY
Empire Building, Pittsburgh, Pennsylvania

IRON AND STEEL ENGINEER

AUGUST • 1941

VOL. XVIII NO. VIII

In This Issue

Floating Motor Drive for Roller Tables—By A. M. MacCutcheon, Vice President, Engineering, Reliance Electric and Engineering Company, Cleveland, Ohio..... 24

Observations on Design and Operation of Rod Mills—By Louis Moses, Superintendent, Rail Mill and Roll Department, Bethlehem Steel Company, Sparrows Point, Maryland.... 30

Discussion: Observations on Design and Operation of Rod Mills—Presented by J. W. Sheperdson, R. M. Hussey, C. E. Johnson, and Louis Moses..... 35

Anti-Friction Bearings for Crane Wheels..... 38

Building-up and Hard-facing in the Steel Plant—By L. Ames, Supervisor, Applied Engineering Department, Air Reduction Sales Company, Pittsburgh, Pennsylvania..... 40

Discussion: Building-up and Hard-facing in the Steel Plant—Presented by W. S. Walker, C. C. Keyser, L. Ames, L. J. Gould, J. B. Whitlock, and Louis Moses..... 47

Application and Care of Bearings in Steel Plant Auxiliaries—By F. L. Gray, Lubrication Engineer, Carnegie-Illinois Steel Corporation, Gary, Indiana..... 50

Discussion: Application and Care of Bearings in Steel Plant Auxiliaries—Presented by S. M. Weckstein, W. C. Bauer, G. F. Bowers, F. J. Thomas, F. L. Gray, W. H. Mandy, J. L. Haynes, and E. S. Glauch..... 55

Sintering of Iron Ore—By E. W. Shallock, Chief Engineer, American Ore Reclamation Company, Chicago, Illinois.... 59

Discussion: Sintering of Iron Ore—Presented by A. J. F. MacQueen, E. W. Shallock, E. A. Rohrig, S. P. Osgood, C. P. Betz, L. S. Voigt, E. J. McCleary, W. H. Collison, R. L. Scholz, and John Heald..... 62

Comparison of Soaking Pit Designs—By F. E. Leahy, Fuel Engineer, Youngstown Sheet and Tube Company, Youngstown, Ohio..... 64

Discussion: Comparison of Soaking Pit Designs—Presented by P. M. Offill, F. E. Leahy, M. J. Conway, G. R. McDermott, C. H. Williams, H. N. Holstein, and Frank Roberson..... 71

Latest Design and Equipment for the Industry..... 77

Items of Interest..... 90

Tentative Program for A.I.S.E. Annual Convention and Iron and Steel Exposition..... 92

Index to Advertisers..... 9

Published Monthly by

ASSOCIATION OF IRON AND STEEL ENGINEERS

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879

Statements and opinions given in articles and papers appearing in "Iron and Steel Engineer" are the expressions of contributors, for which the Association of Iron and Steel Engineers assumes no responsibility.

Copyright, 1941, The Association of Iron and Steel Engineers

Single Copy Foreign Prepaid $2.00 Single Copy $1.50
Subscription price in U. S. & Canada.....$ 7.50 per year
Subscription price in foreign countries.....$10.00 per year

PLASTIC BINDING U. S. PATENT NO. 1870285 LICENSE NO. 50

NEW PRODUCTION CAPACITY?

GET IT ROLLING...

KEEP IT ROLLING

with Westinghouse factory-assembled, ready-to-use control

Quickest and simplest way to get steel mill auxiliaries into action . . . and to KEEP them going . . . is with ready-to-use, factory-assembled and tested Westinghouse control. This "packaged control" is tailored to measure from standard units, and engineered for the job . . . whether the job involves control for *all* the auxiliaries in a new mill, or additions or changes in existing equipment.

Self-supporting structure eliminates need for field erection—sectional design makes it easy to add additional units. Control is shipped as a unit. You simply make incoming and outgoing connections, and the production equipment involved is ready to go into action. Write for booklet B-2265 for details and helpful application data. WESTINGHOUSE ELECTRIC & MFG. COMPANY, EAST PITTSBURGH, PA., Dept. 7-N.

Westinghouse Type SM Contactors
STAY ON THE JOB

Westinghouse SM Contactors reduce number of "time-outs" because the rapid motion and quick extinction of the arc minimize burning. Contact tips are extra heavy, extra durable, easily replaceable. Bearing pins and bushings are of long-life nitrided alloy steel. Vacuum and pressure impregnated coil protected against moisture, dirt, metallic dust.

J-21154

Westinghouse
STEEL MILL CONTROL

The NEWS DEFENSE EDITION

VOLUME XVIII NUMBER 8 AUGUST 1941 CLEVELAND, OHIO

NORTH AMERICAN FIRES GAS OR OIL IN SAME EQUIPMENT

FOR DIFFERENT TEMPERATURES ON SAME FURNACE

The system will burn gas during low temperature operations and oil during high temperature operations on the same furnace. This change can be made by simply opening and closing valves.

FOR DIFFERENT SEASONS

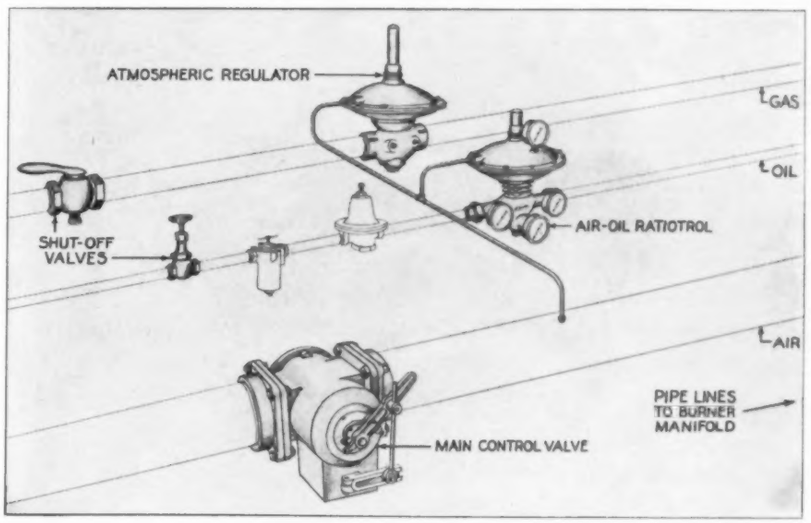
Many Gas Companies furnish gas at an especially attractive rate when used on an off-peak contract. The above system fills the requirements of standby equipment and simplicity of changeover. It is also being used by farsighted plant managers who fear that world conditions may change their fuel position.

SIMILAR FLAME CHARACTERISTICS WITH EITHER FUEL POSSIBLE

By changing the insert of the standard Luminous Flame gas burners, a low pressure air atomizing oil burner can be provided. The same air valve controls the air and gas or oil supplied to the burners.

One Air Valve Controls Fire For Any Number Burners Either Gas or Oil

Fuel-Air Ratio Automatically Controlled By Pressures



In the North American pressure system of proportioning, the oil or gas is directly proportional to the air pressure on the downstream side of the main air control valve. Thus, air or fuel pressure variation, or number of burners in operation have no effect on fuel-air ratio, and thus maximum efficiencies are maintained.

Furthermore, the firing rate or fuel-air ratio of any burner can be changed in respect to the other burners without affecting their fuel-air ratio.

We cordially invite you to write for Engineering Data. The North American Manufacturing Co., 2910 E. 75th St., Cleveland, Ohio.—Adv.

A Modern 15-Ton, 120-Foot Span *All-Welded* Mill-Type Crane. One of 15 Duplicate Cranes on One Order.

FIRST ALL-WELDED CRANE BUILT IN 1926

The idea of building a completely all-welded crane was revolutionary in 1926. Skeptics said, "You can't trust welds." But with many years of practical welding experience Cleveland felt confident that all-welded cranes could be built — and, of prime importance, built better than ever before.

So the world's first all-welded crane was built and erected. And for 15 years it has been traveling up and down its runway, lifting and placing loads of every character, some far beyond its rated capacity. As far as inspections can determine, it will serve as many more years with extremely little maintenance.

Because of the success of the first crane, more all-welded cranes were built and more knowledge of this method of construction learned. Finally, we were convinced beyond all doubt that the all-welded crane was not only far superior, but *the crane of the future*. Therefore, after more than a quarter century of conventional crane construction we decided to change over and standardize on the welded method of fabrication.

The wisdom of this decision may be better determined by the events that have since transpired. Hundreds of Cleveland all-weldeds have been built. The greater part of these are serving the tough jobs in steel mills. They will be found in nearly every modern mill built in recent years. Welded cranes have thoroughly proven themselves.

The idea that was a radical innovation in 1926 has become a respected practice in 1941. The "Crane of the Future" is now *the Crane of today*.

15th ANNIVERSARY
CLEVELAND *All Welded* CRANES

THE CLEVELAND CRANE & ENGINEERING CO.

WICKLIFFE, OHIO.

▲ OF all materials necessary for national defense, steel is the most important and the one most largely used. Of all the basic industries, the steel industry is the best prepared to meet the demands imposed upon it by the present national emergency. One of the most important factors responsible for this state of preparedness is the development, over the past 15 years, of the continuous and semi-continuous strip and plate mills. Designed and built for the most economical and rapid production of sheets for automobile bodies, refrigerators, railroad cars, tractors, ships and innumerable other uses, these continuous mills now stand ready and waiting to deliver the same type of product for cruisers, destroyers, cargo ships, army trucks, gun mounts and tanks.

FLOATING ROLLER

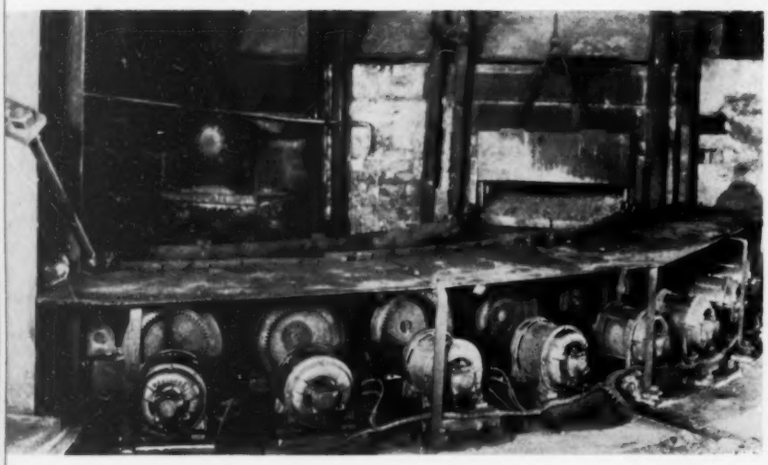


Figure 1—Early installation of curved table for conveying billets, using individual roller drives through gearing.

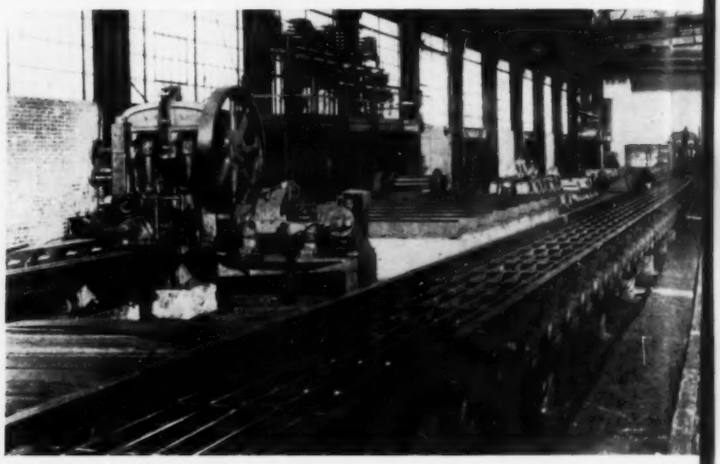


Figure 2—Another early installation of individual roller drives, with motor rotor mounted on extension of roller shaft.

Less than five years ago, many felt that there were already too many continuous mills and that the building of more would be an economic waste. Since that time, several have been added and more are under construction. The vision of the steel mill executive has again been vindicated.

One of the most important auxiliaries of the continuous mill is the roller table where the rollers are operated singly or in pairs by individual motors. It is with a new development in the driving of these rollers that we are particularly concerned in this paper. The problems which are met in the efficient, economical and convenient handling and coiling of strip sometimes appear more complex than those which are met in the actual continuous rolling of the steel. Many papers have been presented before the Association of Iron and Steel Engineers on table drives. These papers have presented the relative advantages of individual drive over group drive, have discussed the characteristics of the motor which would give the most rapid acceleration and reversal, have treated of the power required for reversal, have outlined the methods of determining the capacity of motor-generator sets required for the operation of the motors, have pointed out how quick stopping of a-c. motors may be secured through the introduction of d-c. into the stator circuit and have shown how either d-c. or a-c. may be used to accomplish adjustable speed of those sections of the tables where it is required. In this paper the discussion is more particularly directed to how the power may be most effectively transmitted from the motor to the roller. The more important considerations in designing the drive of a roller table are to secure maximum flexibility, freedom from shut-down, the minimum of maintenance and simplicity in table construction. Individual or duplex drive is preferred over group drive since line shafts and the accompanying gearing occupy valuable space, interfere with the handling of the product, are difficult to maintain in alignment and complicate the removal and replacement of rollers. If alignment is not maintained in group drive from a single motor, abnormal power demands result.

Some twenty to thirty years ago, the first individually driven rollers went into operation. As in the case with most pioneering applications, certain difficulties were not foreseen. In one of the earliest applications, the roller was carried directly on the motor shaft. This

Motor Drives for TABLES

By A. M. MacCutcheon

Vice President in Charge of Engineering

RELIANCE ELECTRIC & ENGINEERING COMPANY

CLEVELAND, OHIO

Presented before the Birmingham Section, February 24, 1941

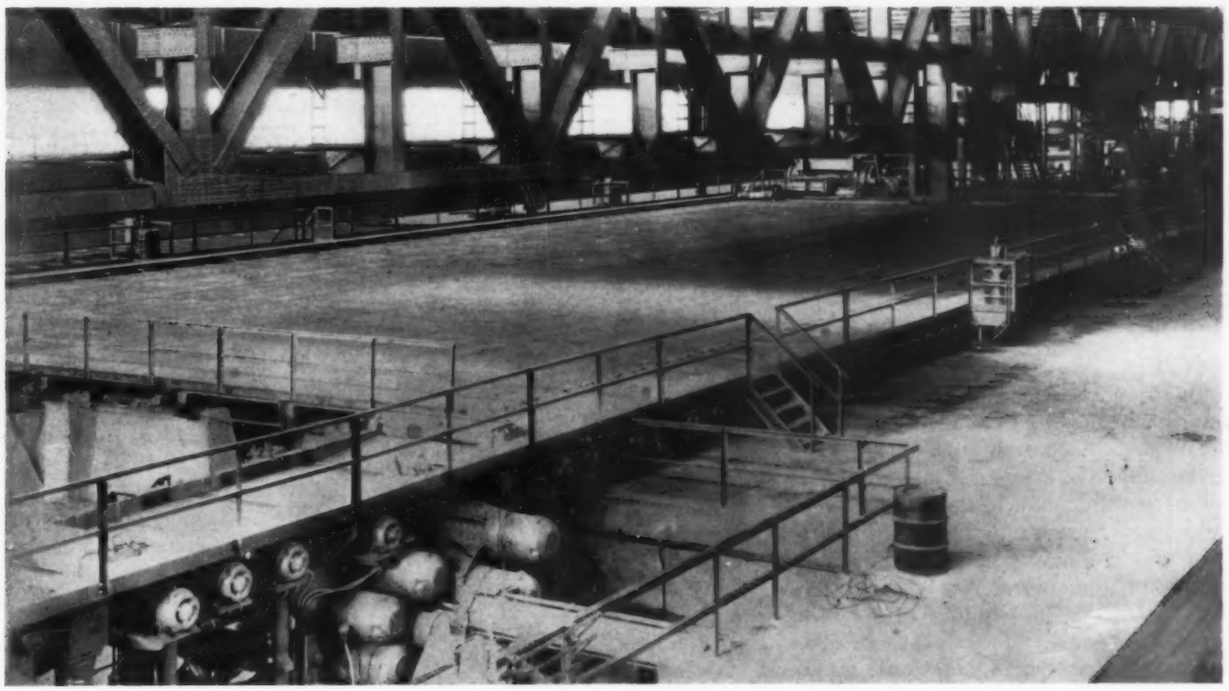


Figure 3—In this installation, the individual open ball-bearing induction motors are shielded by the table runway.

construction is ideal where the roller is narrow and the weight of the roller not greater than that which can be successfully carried on the motor bearing. The rpm. of the motor is the same as the rpm. of the roller.

About 1923 an interesting table was installed for handling billets around a curve and is illustrated in Figure 1. The motor is geared to the roller through open type gearing which would not now be tolerated. This table is still in operation and is giving a very satisfactory account of itself.

About the same time, a German mill developed a roller carried on a stationary shaft and with the motor built inside the roller. The stator core and the primary windings were carried by the stationary shaft, and the squirrel-cage winding on the outside of the stator was mounted within the roller. The roller was carried on the stationary shaft by ball bearings. The motor might be described as an inverted induction motor. This construction eliminates the necessity of any mechanical connection such as a coupling between the motor and the roller.

On one of the early individual drive roller tables located near Pittsburgh and which went into operation

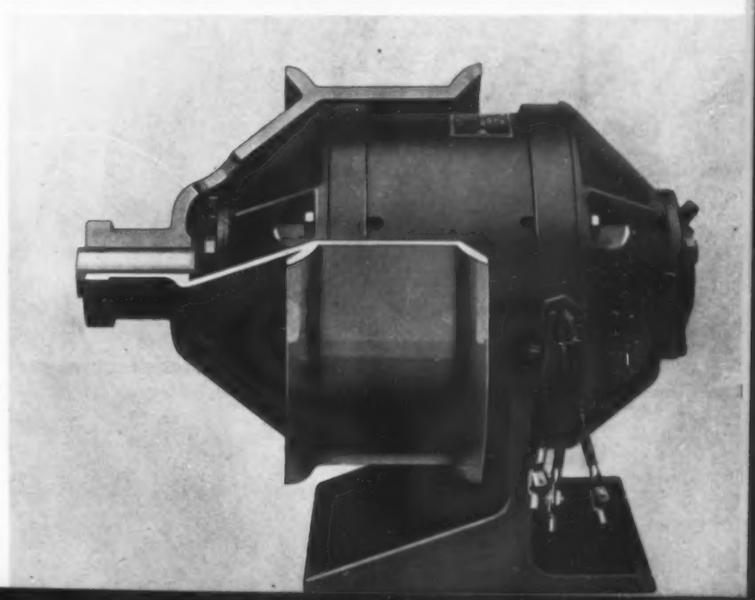


Figure 4—This motor, with roller mounted on extension of motor shaft, is applicable principally to narrow mills, such as cotton tie mills.

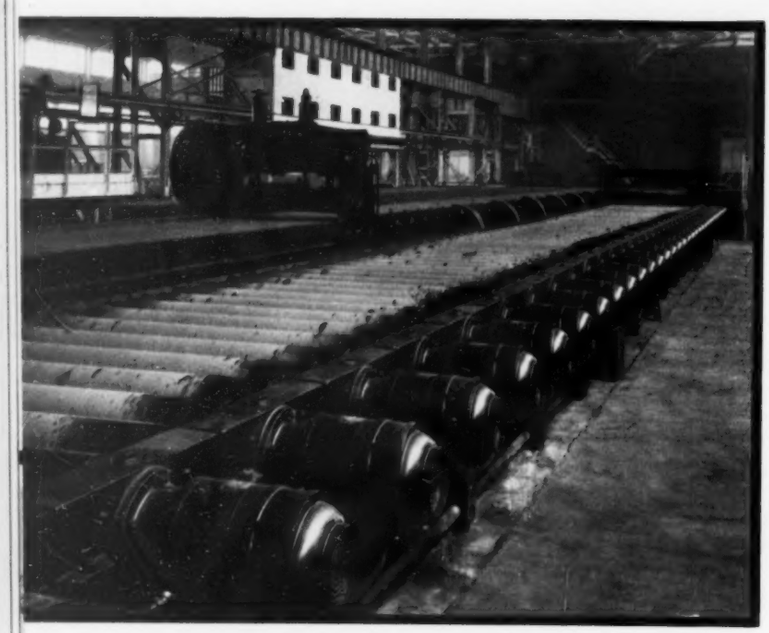


Figure 5—This wide strip mill installation employs two rollers driven from a single flange mounted motor through gearing.

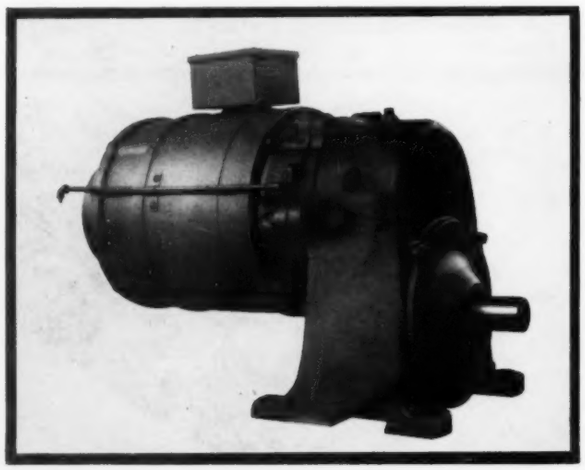
about 1926, the rotor of the induction motor was mounted on an extension of the roller shaft and with no outboard bearing. From Figure 2, it is evident that the stator is flange mounted to the side of the table. This would have been an ideal way of transmitting the power from the motor to the roller if accurate alignment could have been secured and maintained. However, considerable difficulty was experienced due to the rotor rubbing on the stator. Analysis indicated four causes of trouble acting individually or in conjunction. First, warpage of the roller due to heating and cooling; second, unequal settling of the table; third, variation in machining of the motor stators and the supports for the stators on the side plate of the table; fourth, the roller shaft extension was not large enough in diameter to successfully resist the stresses due to the weight of the rotor and the magnetic side pull resulting from uneven air gaps.

About 1928 there was installed in the Cleveland district, individually driven roller tables handling the product from a 42 in. continuous mill. As can be seen from Figure 3, this was an early installation of the more modern type. The motors were connected to the rollers through a flexible coupling. Open ball bearing motors were used and were protected by the runway along the table. Since the motors were open and the expected duty well defined, Class A insulation was employed and has proven highly satisfactory. The rollers driven by squirrel-cage induction motors could be brought to a rapid stop through introducing direct current into the stator windings. Power to the motors was supplied from an alternator connected to direct current adjustable-speed motors.

In the southern district, as well as in St. Louis, are mills producing narrow strip largely used for "cotton-tie." The roller table comprises a number of motors with the roller mounted on an extension of the motor shaft and overhanging the motor. Figure 4 shows the construction. The motor is supported by a single flange carried on a broad foot. The installation has been very successful but this "pulley type roller" is limited to narrow mills as is evident from the construction.

Many modern mills have two rollers driven from a single motor through gearing. This permits of a reduction in the number of motors and conserves space. The motor is flange mounted to the side of the table bed, and torque is transmitted to the two rollers through a pinion mounted on the motor shaft engaging a gear at either side. Since the motor rpm. is higher than that of the roller, the size and weight of the motor are reduced and there are one-half as many motors as rollers. The detail construction of such a mill is indicated in Figure 5, which shows a typical modern installation in the Pittsburgh district. This is a large mill and the power for several hundred rollers is supplied from five motor-generator sets. Each alternator is driven by two 300 volt direct-current motors connected in series and supplied from the same busses which supply the power to the main mill motors.

Figure 6—The geared head motor may be required where duty is particularly severe and space is at a premium.



Where the duty on a roller is particularly severe and where the rollers are so close together that space is at a premium, a geared head motor may be required, and many of the modern installations make use of this type. As is readily recognized, a smaller motor will develop the higher horsepower required and operate at a speed higher than the required speed of the roller. Such a geared head motor is illustrated in Figure 6 and was used in a mill in the Detroit district.

If space and economics permit, the ideal engineering application is a motor direct connected to the roll, as typified in Figure 7. This was used in a southern strip mill and also on a plate mill in the Pittsburgh district. Connection between the motor and the roller is through a flexible coupling. Even with individually driven rollers, the maintenance of alignment between the motor and the roller is essential. When misalignment occurs, the best type of coupling or gearing may not operate

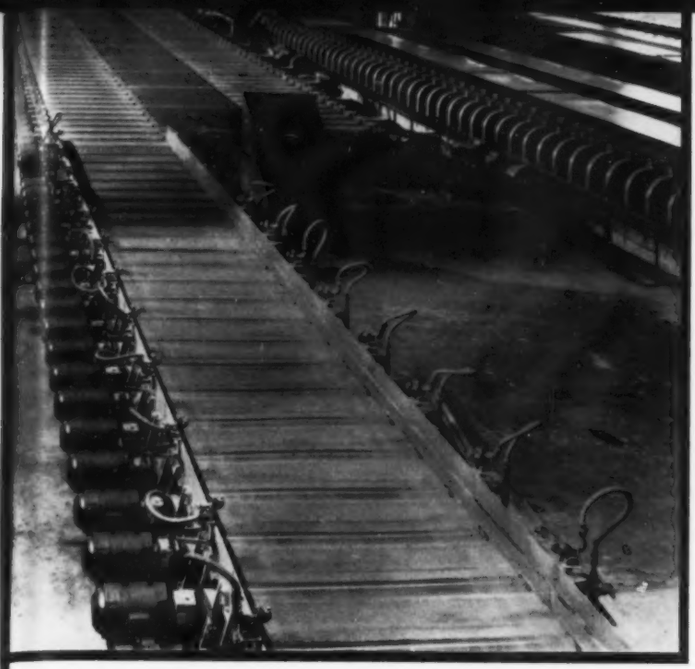


Figure 7—A common installation is the individual motor direct connected to the roller through a flexible coupling.

successfully. The roller is conveying hot steel with severe changes in temperature. The distance between the bearings supporting the roller is great—sometimes over 100 in. The foundation for the table may settle. Any or all of these causes may produce misalignment between the motor and the roller with consequent excessive maintenance. On several very modern mills, a considerable amount of trouble developed due to such misalignment in connection with the coupling or gearing connecting the motor to the roll. This trouble was sufficiently serious to cause much study and research in order to develop an improved type of drive.

One mill in the Detroit area using twin rollers driven through gearing from a single motor (Figure 8) very ingeniously replaced this gear drive with a V-belt drive which has given entire satisfaction on a large number of rollers. Later, this type of drive was introduced experimentally into a Pittsburgh district mill where trouble had been experienced, and the experimental drive has successfully operated for considerably over a

Figure 8—This installation, originally twin rollers driven through gearing by a single motor, was changed to V-belt drive.

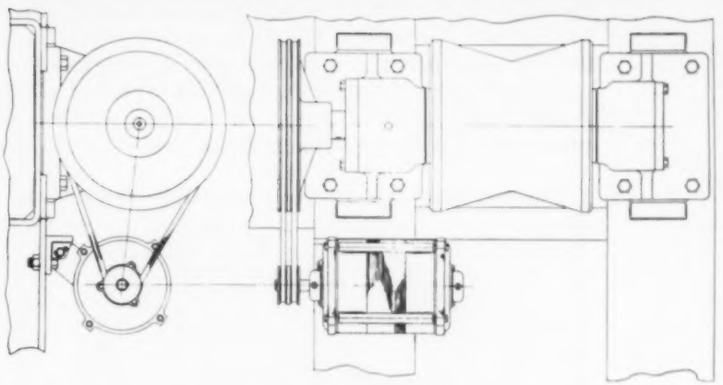


Figure 9—Typical layout of V-belt drive for table roller, with motor carried on pivot pin.

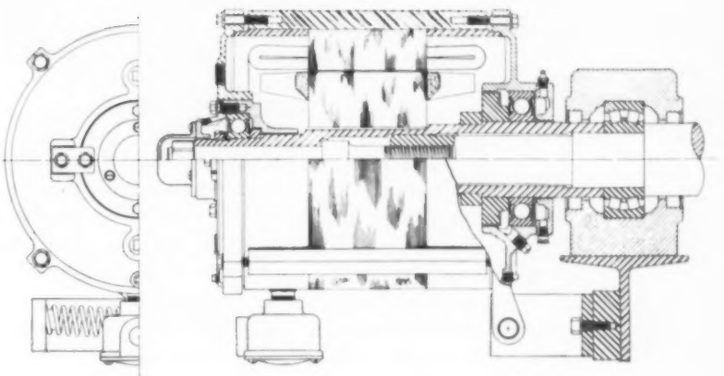
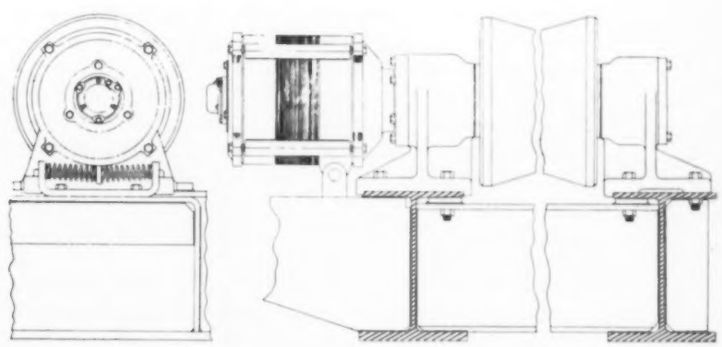


Figure 10—Cross-sectional view of floating motor drive, showing how entire motor is carried by the roller shaft extension.

Figure 11—Typical application of floating motor drive to a tube mill table roller.



year. Where a reduction in speed from the motor to the roller is essential, it is felt that this type of drive has great possibilities. While some belt wear may develop, especially if very rapid acceleration or deceleration is necessary, the belts are relatively inexpensive and readily replaceable. A typical layout of such a drive is presented in Figure 9. The motor is carried on a pivot

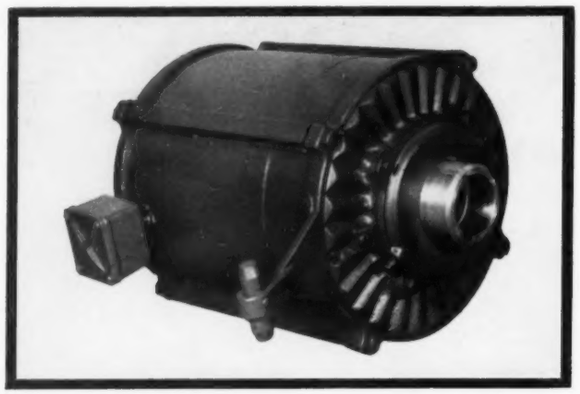


Figure 12—Floating motors of this type have given excellent trouble-free service for mill table drives.

pin, giving automatic belt tightening and permitting very easy replacement of the belt. Such a drive appears to be entirely free from trouble due to misalignment.

Summarizing, on modern tables having individual or twin roller drive, the torque is transmitted from the individual motor to the roller or rollers by means of either a flexible coupling or gearing. The motor is supported from its feet on a suitable mounting. If, for any reason, there be misalignment either on installation or which develops later, either coupling or gearing may not be able to withstand this misalignment, in which case trouble and maintenance results.

About three years ago, an engineer much interested in roller table drives commented to another engineer equally interested that there seemed to be more trouble assignable to the device connecting the motor to the roller than to all other causes combined. He asked whether it might not be possible to develop a new type of motor mounting free from all trouble that had been experienced with the various methods previously used. Could there not be something in the nature of a "floating power drive"? Following this conversation, there was an extended period of intensive study and design resulting in what has been called "floating motor drive." It is this drive that I wish to describe. Early in this study, the following principles were established as fundamental:

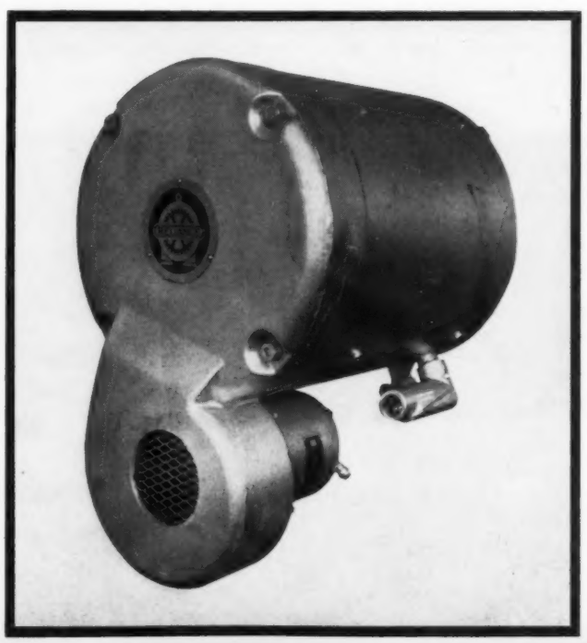
1. The motor rotor must be an integral part of the roller with no possible relative movements between them.
2. The motor rotor and the roller must be carried on the same set of bearings.
3. There must be no possibility of the rotor being displaced with reference to the stator so that there may be no change in air gap.
4. The motor must be readily applied to and removable from the roller.
5. The motor must operate the roller successfully even though the roller is not level.
6. The motor must operate the roller successfully even though the roller be warped.

As illustrated in the cross-sectional view (Figure 10), the "floating motor drive" was designed with the rotor mounted on a sleeve which, in turn, is mounted on and keyed to the shaft extension of the roller. The rotor of the motor is then an integral part of the roller and there can be no relative movements between them. Since the rotor is entirely supported from the shaft extension of the roller, they are both carried on the same set of bearings and the first two principles have been met. The motor stator is carried from the rotor sleeve through ball bearings, and principle 3 is satisfied since the stator is carried from the rotor and there can be no relative movements between them except as transmitted by the ball bearings. Rotational movement is not interfered with.

The roller shaft extension is drilled and threaded to receive a screw. The unthreaded shank of this screw passes through, and is supported by, the rotor sleeve. Endwise motion of the screw with relation to the rotor sleeve is prevented by a shoulder on one side and a pinned nut on the other. The completely assembled motor is drawn onto the roller shaft extension by starting the screw in the threaded hole in the roller shaft extension and turning the screw clockwise. Since there can be no lateral movement of the screw with relation to the rotor sleeve, as the screw enters the shaft extension of the roller it carries the whole motor with it, forcing the rotor sleeve over the roller shaft extension. When the screw is turned in the opposite direction, the rotor sleeve is forced off the roller shaft extension—the whole motor being carried with it. Mounting the motor on the roller shaft extension is as simple as the mounting of a coupling or gear, while removing the motor is much simpler. The motor is readily applied to and removed from the roller, and principle 4 has been satisfied.

To prevent rotation of the stator when power is applied, the rear motor bracket is supplied with a lug

Figure 13—A small separately driven blower for forced ventilation may be mounted as part of the floating drive unit.



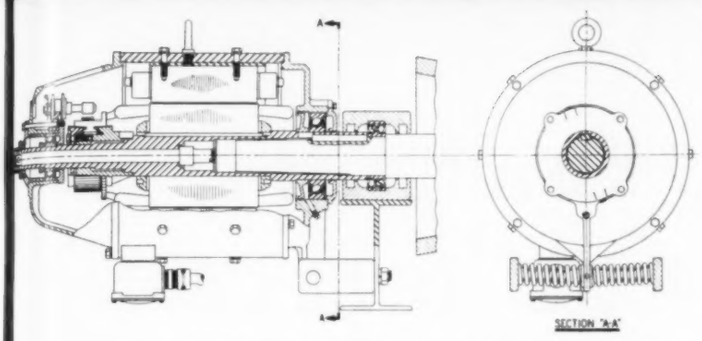


Figure 14—Cross-sectional view showing floating motor principle as applied to d-c. motor.

extending downward. To this lug are attached two coil springs extending in opposite directions. One of these springs extends to the right of the lug and the end of the spring is suitably anchored to the table bed. The other spring extends to the left and is similarly anchored. These springs prevent rotation of the stator and, through the springs' reaction, compel the rotation of the rotor and, therefore, the roller. The springs not only prevent rotation of the stator but also cushion the starting of the motor in a most remarkable manner. With the motor running under a steady load, there is no perceptible deflection of either of the springs. While it was believed that this design would operate successfully with the roller in any position and even though the roller were warped, thus meeting principles 4 and 5, it was necessary to prove this belief correct. A sample motor and roller was built and successfully demonstrated in the laboratory. With the roller displaced 30 degrees from the horizontal, operation was unaffected. The roller shaft extension was deliberately bent so that the outer end of the motor was $\frac{1}{16}$ in. out of line with the bearing of the roller. The resulting wabble had no harmful effects at all, and at the operating speed of a motor roller the vibration did not appear at all excessive or harmful.

After the completion of these experiments, a sample roller was built and installed in an existing mill table in the Youngstown district and has been operating successfully for considerably over a year.

Figure 11 illustrates a typical application of such a motor to a tube mill roller. No particular attention need be paid to the structural members' supporting the roller being in alignment. Since the motor is supported on the roller shaft extension, no matter what the position of the roller shaft, the motor follows it. The U-shaped clamp to which the springs are fastened can be mounted on any fixed part of the table. It is not necessary that the springs extend at right angles to the lug. They may be in any position with relation to the lug which prevents rotation of the motor stator. The roller table may be carried from two I-beams which do not necessarily have to be level. The table construction can, therefore, be exceedingly simple and inexpensive. It is essential that the bearing between the motor and the roller have sufficient capacity to carry the weight of both.

About one year ago, 32 units equipped with "floating motor drives" went into operation in a southern mill and have been entirely trouble-free excepting that a few springs required replacement. The springs originally supplied were not quite stiff enough to match the torque developed by the motor. In the near future, several hundred of these drives will be installed in the same mill. The type of unit installed is illustrated in Figure 12. Figure 13 shows an interesting modification where a fan-cooling effect is provided by a separately driven small blower mounted as part of the floating power unit. In this construction, there is continuous cooling even though the roller may be operated at very slow speeds or be reversed much of the time.

Since it is intended that the motor shall be entirely supported by the roller and quite free from any other rigid support, flexible leads are used to connect the motor to the line. The reacting springs permit only a very small rotational movement of the stator—usually less than 1 in. from the neutral. The amount of movement may be controlled by the stiffness of the spring. A less stiff spring provides a greater cushioning on starting or reversing the motor.

On certain sections of a roller table, adjustable speed is necessary in order to match the changing speed of the main drive. This adjustable speed may be secured either with the use of a-c. motors and a motor-generator set consisting of an alternator driven by an adjustable speed motor or by the use of d-c. motors with varying voltage from a d-c. generator driven by a constant speed a-c. motor. Decision between alternating current and direct current is almost entirely a question of economics. Usually, first cost and maintenance favor the a-c., whereas efficiency and space for a motor-generator set is on the side of the d-c. In any particular instance, the situation should be analyzed from the standpoint of both a-c. and d-c. and that type of drive selected which best meets the particular requirements. The "floating motor drive" is equally applicable to either a-c. or d-c. motors, and Figure 14 shows it applied to a d-c. motor. There will be much less vibration on the d-c. motor than through a coupling drive when misalignment exists. Commutation will be entirely satisfactory.

While the cost of a motor with a sleeve and a drawing on screw is somewhat greater than the cost of a standard motor, there are a number of compensations. The coupling and the cost of its mounting are eliminated. The structure supporting the mill table can be very simple and inexpensive. The roller and its driving motor may be removed from the table as a unit—simply disconnecting the flexible leads. Any lining up between the motor and the roller is entirely eliminated. Misalignment is impossible. Due to the elimination of the coupling, the over-all length can be somewhat decreased. The development so far has been confined to replacing direct-connected motors by "floating motor drive." Some design work has gone forward with a view to producing a unit which would replace geared head motors. Since the motor speed would then be different than the roller speed, the geared head would be supported from the roller extension and the motor, in turn, supported from the geared head. Such a drive may be entirely successful but should come only after further experimentation and a trial installation, since the problems to be met are considerably more complicated than in the case of the direct-connected motor.

Observations on DESIGN and OPERATION of ROD MILLS

By Louis Moses

Superintendent Rail Mill and Roll Dept.

BETHLEHEM STEEL COMPANY

SPARROWS POINT, MARYLAND

Presented before A. I. S. E.

PHILADELPHIA DISTRICT SECTION

December 7, 1940

▲ THE early conception of a rod being a crudely produced material is rapidly changing. This is brought about through the demands of the trade for an ever increasing degree of sectional accuracy with more exacting control and adherence to other features. As furnished to the users in various gauges, and coiled into varying weights, rods are the supply from which wire is drawn and from which rivets, bolts, screws, and the innumerable products of the upsetting machine are made.

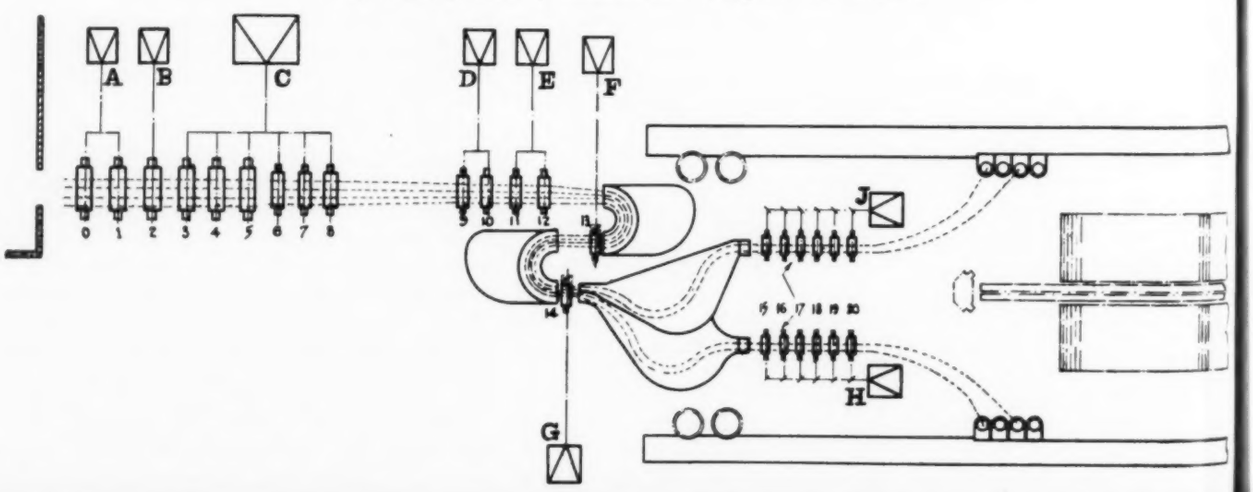
Rod mills exist on which sections smaller than No. 5 gauge can be made. However, it is generally recognized that a nominal No. 5 gauge is the minimum economical size.

As occurring over the years the calls for coils lighter than 300 lb. have diminished. Generally a lighter specification comes from a user whose facilities for handling are confined to manual labor, or whose capacity in the wire drawing blocks is limited. Some users demand a 400 lb. coil. A quantity of coiled rod is sometimes referred to as so many bundles, showing the generic influence of the wire mills.

The tendency in the direction of heavier coils is based upon the consumer providing himself with the fewest number of individual lengths per unit of output so as to reduce handling expense. On the screw and upsetting machines this provides for a fewer number of feedings during the day's operations. Mills and customers have joined hands in this and the best practice is being gradually worked out in the interests of everyone concerned.

The No. 1 rod mill at Sparrows Point, constructed in the year 1926, produces coils of 300 and 400 lb. weights in a range of sizes from No. 5 gauge to ½ in. diameter. These sizes are rolled in two strands from 1 15/16 in. and

Figure 1—Layout of rod mill totaling 27 roll stands and including two finishing trains, permitting simultaneous rolling of four strands.



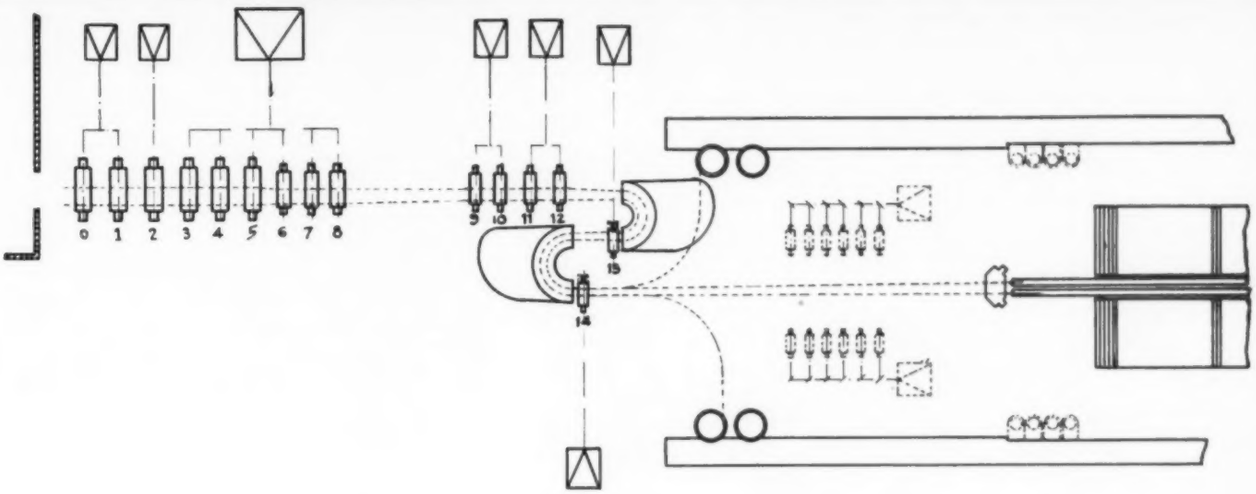


Figure 2—Layout of mill in Figure 1, showing mill set-up when finishing two strands from No. 14 stand.

2 in. square billets, respectively, both 30 ft. long, and are coiled in a battery of four laying reels.

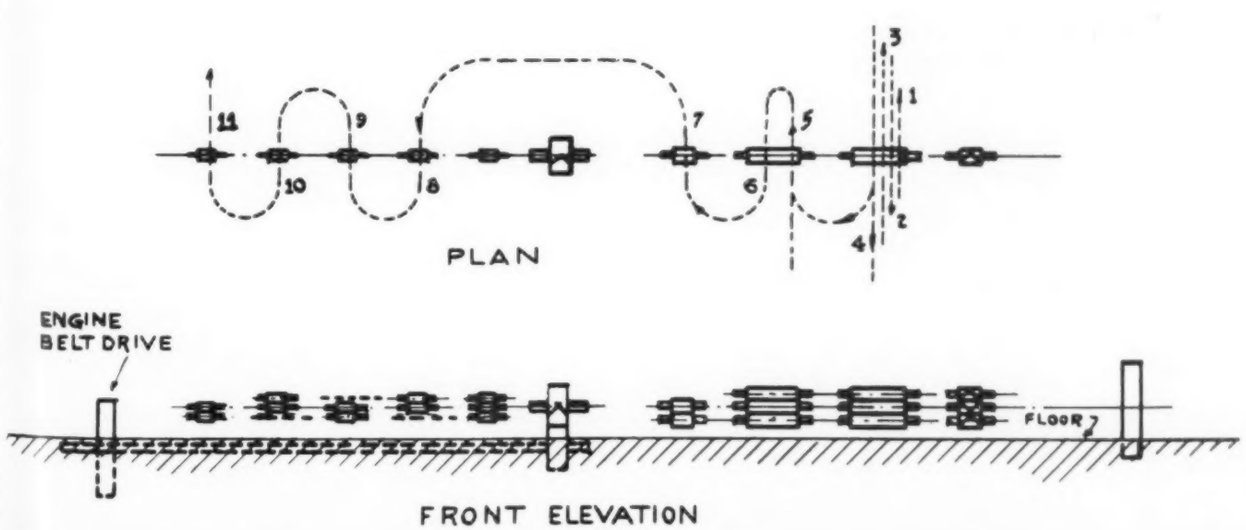
The No. 2 combination rod and bar mill has recently been enlarged in its capacity to roll rods, by the addition of a second six stand finishing mill which duplicates the original unit of the same number of stands. This additional outlet, with its complementary reels and conveyors, permits the rolling of four strands simultaneously and, in such an essentially arranged tandem mill, becomes the only application of the kind in this country.

The mill is provided with three outlets. Figure 1 shows the mill set up with all 27 stands of rolls. It will be noted that 21 passes are actually in operation on each bar when No. 5 gauge is rolled from a 2 in or 2½ in. billet. The eight laying reels, in batteries of four each, receive up to ⅜ in. sizes and alternately coil the four bars.

Figure 2 shows the same mill but with the product from No. 14 stand being delivered to four pouring reels, arranged in pairs of two each, and coiling bars from ⅜ in. to ¾ in. which are rolled on a two strand schedule of passes. As also shown such double strand rolling may be delivered as straight bar to the hot bed.

Bars over ¾ in. and up to 1⅛ in. diameter are singly

Figure 3—Sketch showing the application of three-high mills to the Belgian type mill for rolling rods.



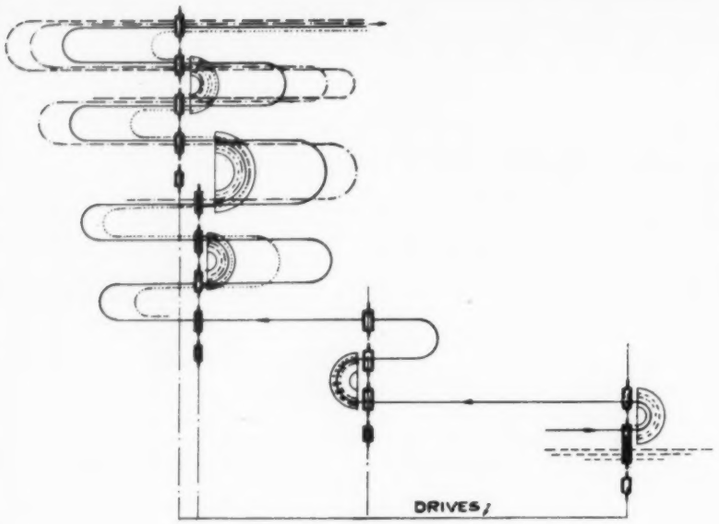
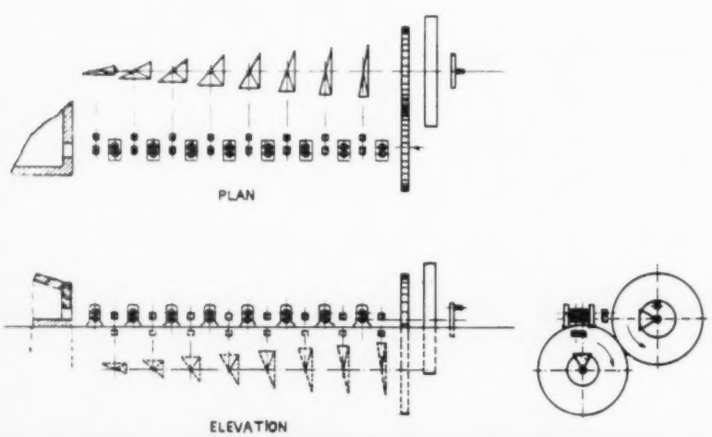


Figure 4—The early Garrett mill used an arrangement as shown here, and was fed from a stand of three-high rolls.

rolled from 3 in. square billets for straight delivery to the hot beds whereas bars below ¾ in. diameter are rolled double strand, each strand being delivered to one side of the bed.

The production of a quality rod in volume and at a fair return for the invested capital and efforts expended is not accidental. From the earliest days of the industry each new rod mill was built upon the experience gained in earlier construction. In this, all the known advantages were retained to which was added an advanced technique and the desired design to accomplish same. This principally became a striving to shorten the time required to reduce a large section to the small area of a rod, and thus lessen the time during which the small section rapidly cooled.

Figure 5—In the Bedson mill shown here, the axes of the rolls are arranged in alternate vertical and horizontal positions.



The John Fritz invention of three-high rolling mills, and its introduction at Cambria Iron Company, Johnstown, Pennsylvania, in 1857 was the first advance and eliminated by nearly one-half the time of rolling which had been consumed on the "pull-over" two-high mills used up to that time.

Figure 3 shows an evolution of this idea as it was applied to a Belgian (or open type) mill for the rolling of rods. The limiting factor of such a representative combination of roll stands is the celerity with which the break-downs can be delivered from the roughing mill to supply the succeeding finishing stands. Coils of 40 to 50 lb. weights were thus produced through the 1880's and 1890's at a rate probably not greater than 40 tons per day.

Incidentally, this particular mill had its proportionate share in rolling the rods used for fence wire which was so much in demand in the country's then expanding West.

But other types were being evolved and constructed with the above stated objectives in view. Disregarding for the moment the consecutive order of these, a jump is made to 1882 when the first Garrett mill is reputed to have been built at Cleveland, Ohio.

Mr. Garrett recognized that the weight of a 5 in. x 5 in. x 1 ft. long billet is the same as that of a 1¼ in. x 1¼ in. x 16 ft. long billet. The difference in the surface area is approximately 75 per cent less for the larger size. He reasoned that this factor provided greater ease of handling the billet in the furnace and that the breaking down of such billet sizes to a corresponding section of a 1¼ in. square could be readily accomplished.

He devised the arrangement shown on Figure 4 and fed this mill from a stand of ordinary three-high rolls. The speed of breaking down the billet is short, compared with the time required to work upon the long lengths in succeeding stands. Apparently such mills were arranged with one roughing stand serving two finishing mills.

The use of repeaters will be noted. These devices are installed on one side of the open mill and return the delivered bar into the next succeeding pass. Hand catching is used on the opposite side. By this means the long lengths are rolled in a continuous manner but with growing loops on each side of the mill. Hook boys were employed to keep the long loops from entangling but repeaters are in use today which completely eliminate this. The long loop imposed a serious handicap. The weight of the bundle had to be limited so that the loops would remain in their control and so that the variation in temperature would not affect the gauges of the front and back ends of the rod too greatly.

Returning for a moment to the statement that four strand rolling is the first application in this country to an essentially tandem arranged mill, this must not be confused with Garrett mill operations which today roll six strands at one time.

Adaptations of the Garrett type of mill, and of the Belgian or open type mill, but served with six tandem continuous roughing stands in place of the three-high mill, are in use today and roll a very good product.

In the tandem continuous type we have an arrangement offering the minimum cooling to the bar, a decided

advantage in production, and efficient furnaces providing close control of the metallurgical aspects which are so dependent upon heating practice.

Figure 5 illustrates the English patented Bedson mill of 1862 in which the axes of the rolls were arranged so as to be alternately in vertical and horizontal positions. No two successive drafts were to be taken in the same direction. The prime objective is to speed the time of rolling. Obviously this arrangement does not permit multiple stranding.

A Bedson mill was installed about 1869 at Worcester, Massachusetts. Mr. Charles Hill Morgan, then general manager of Washburn and Moen Manufacturing Company, operated it for a number of years but difficulties were such as to cause the abandonment of the idea. He changed the arrangement of the rolls and made them all horizontal, accomplishing the 90 and 45 degree turns of the bar by the invention of twist guides.

Figure 6 shows the No. 1 rod mill at Sparrows Point. The arrangement of the stands is quite representative of the type although this was the first mill to be direct connected by gears to the motor drive. Earlier mills were motor driven, beginning about 1912, but utilized belt transmissions. The 17 stands were not immediately adopted, the earliest had but 14 stands. With the expansion of the wire industry heavier coil weights were demanded and the 1¾ in. (or more properly the 1 13/16 in.) billet for 300 lb. bundles was found to be more readily reduced in 17 stand mills. This offered lessened operating difficulties but aside from this many 16 stand mills are in successful operation all over the world and perform excellent work.

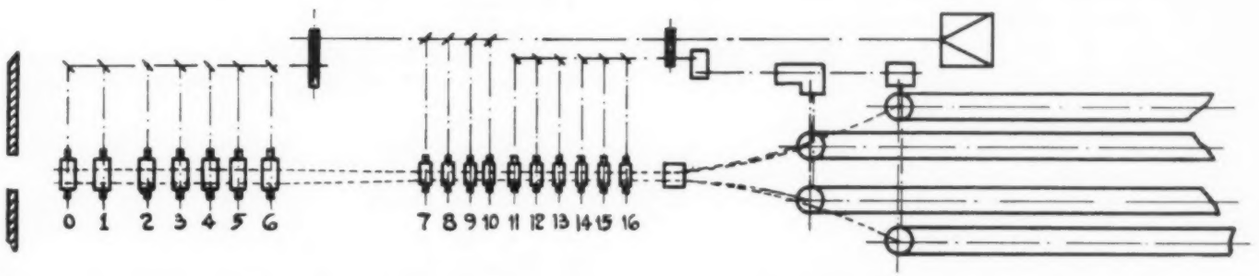


Figure 6—Layout of No. 1 rod mill at Sparrows Point. This was the first mill to be connected to the motor drive by gears.

It will be readily seen that in such close coupled and geared mills a constant volume of stock in a given time must be delivered from each and every stand of rolls. Similarly, every stand must be adjusted to receive a like amount without interruption to the constant flow of material being rolled. On tandem continuous mills such as this the roller operator must regulate this to a nicety or one of two things will happen. If too much stock is being delivered to a succeeding stand, the bar, at the speed it is traveling, will cobble. If an inadequate amount is provided to the succeeding stand, a pull results. Adjustments can also be made which stretch the bar and actually reduce its area.

Numerous conditions, such as slight variations in temperature, roll diameters and bearing wear conspire to prevent this exact regulation at all times and as a consequence it will frequently be found that the bar is in a state of slight tension rather than the desired balance between stands. The amount of such tension, as it adds up throughout the mill, is measured by the effect it has in off-gauge back ends of the finished coils.

An attempt to explain this effect is by the use of Figure 7. At *A* we see a bar between a single set of rolls but with the ends free to go wherever the rolling action wills. At *B* the same operation is performed in No. 1 rolls but with a later set, No. 2, interfering with the freedom of the front end. Also, and for example, let us consider No. 2 exerting a pull. This influences the area being delivered from No. 1 rolls, which would be larger if the pull were not present. It also influences the area of the bar in No. 2 because, if these were free as at *A*, and all other conditions were constant, the absence of such pull would create a larger area out of No. 2.

At *C* we have the same rolls as at *B* but with the back end emerging from No. 1. Here, with the pull removed, and the entering bar larger, the area of No. 2, in the length of bar thus represented, is also larger. While no overfills or defective action otherwise may be occasioned in the roll grooves themselves the relatively larger volume of stock, particularly in the early stands, is considerable in terms of the finished bar sizes. By just so much is the constant volume of stock throughout the mill interrupted.

Everyone acquainted with rod mills appreciates the respect which is paid to rollers who, by their skill in making roll adjustments, regulate this and other important phases of rolling. If too much pull is allowed to exist between stands it culminates in too great a length of oversize at the back ends of the finished rod coils. The roller's only means of regulation on non-variable speed mills is by correction of the roll settings. Sometimes the need for this is beyond the capacity of the groove contours and compromise must be made to avoid making fins and thus spoiling the bar.

No less skill is necessary in roll settings on mills equipped with split up, variable speed drives, but by means of these considerably more flexibility is obtained. Figure 8 is a representative example of this and through-

out the mill allows closer control of the material's constant flow.

On all tandem continuous mills and with all other considerations except the grade of steel to be rolled being the same, the control of the finished section becomes a function of rate of entry into the initial stand. Assume that a good section meeting all requirements is being rolled of rimmed steel and the schedule then calls for a change to a harder and killed steel. In such instances the roller generally will adjust his rolls by closing up the partings of the first stand only so as to deliver a smaller volume of stock. Should the original setting be retained the denser steel would overfill all of the succeeding passes.

Similarly, if the mill is rolling high-carbon grades and a change to a rimmed, low-carbon, grade is made, the roller will provide a sufficient stock for the rest of the mill by opening up the initial stand of rolls. In other words, the varying densities of steel, in its various grades, exert a decided influence on the rate of entry.

There are combination mills with tandem continuous roughing stands serving succeeding stands which are arranged in cross-country style with variable speed drives and suitably devised looping tables. Sometimes these are followed by a small tandem continuous unit delivering small diameter bars and rods to reels. The determining factor in every design of this kind is the range of products, including shapes and rods, which must be rolled for an individual market.

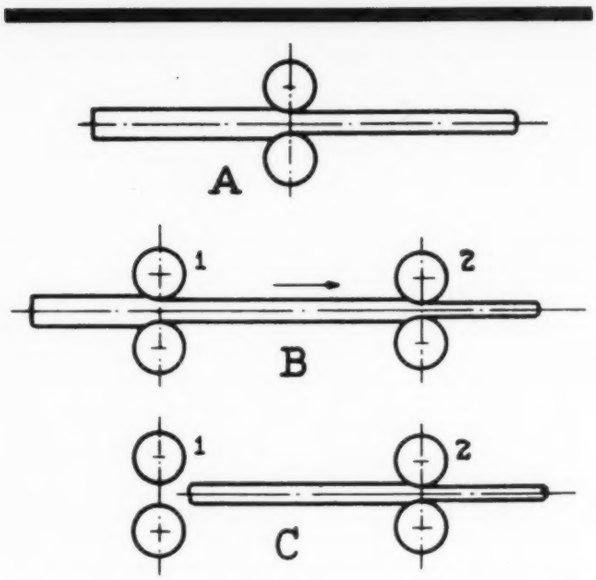
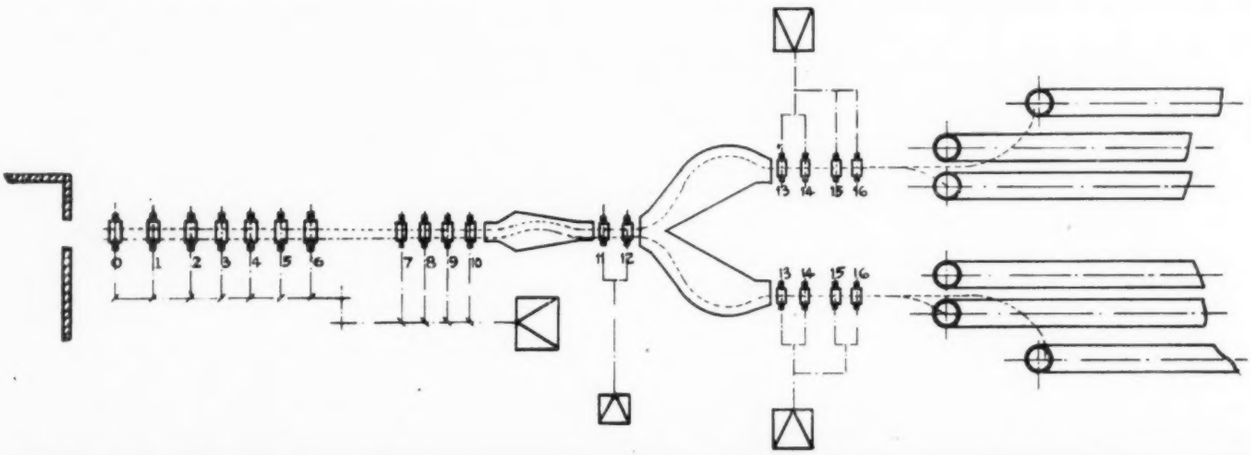


Figure 7—In the tandem mills, tension existing between stands results in a variation of gauge of the back ends of finished coil.

Figure 8—(Below) The use of several variable speed drives on the rod mill gives considerably greater flexibility of operation.

Figure 9—(Right) Sketch illustrating the flow and spreading of metal in the roll passes under various conditions.



The No. 2 combination rod and bar mill shown on Figures 1 and 2 incorporates many of the above considerations together with a design permitting large volume production and efficient controls.

That scheme of pass construction would be preferred which in itself induced a maximum elongation accompanied by a minimum amount of spreading. Obviously a lessened side displacement would be less damaging to bar surface. However, it is not at all possible to state outright that any one particular system of passes is good to the abandonment of another and discrimination must be exercised in the adoption, in whole or in part, of any system of reductions.

Probably the most widely used scheme employs alternately arranged oval-square-oval pass shapes and this appears to be the most rapid means for area reduction on rod mills. Another method consisting of oval-round-oval passes is also used on these mills, especially in the final 6 to 10 stands. Splendid products are efficiently rolled by both schemes, either as a whole, or in combination of the two, and on many mills.

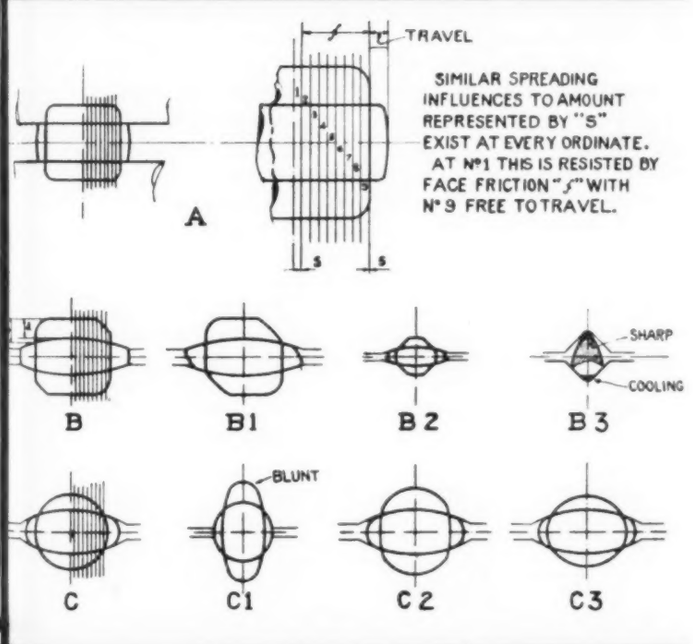
In discussing the flow of steel in the rolling process (IRON AND STEEL ENGINEER, February, 1938), the writer made the statement that the side walls of an oval restricted spreading action of the bar. In the light of the following this statement is not entirely true.

Sketch *A* on Figure 9 illustrates spreading in its

simplest form. It is to be noted that the components of the total spread vary according to the location with respect to the middle to the bar. Unit spread, per vertical ordinate, is greatest at the ends of the section, the differentials being governed by the extent of roll face friction.

At sketch *B* the same entering square is superimposed on an oval. Again by the use of the ordinates we see that the greater vertical reduction at the end zones induces more spreading and that here there is a minimum face friction to be overcome. It is a matter of conjecture as to how much of such relative action between *A* and *B* is modified by the greater end zone drafting going into elongation and by inward flow of stock to the lightly drafted middle ordinates.

As indicated by *B-1* the corners of the squares are sometimes underfilled. When squares become in the order of 5/8 in. sizes, and particularly down to the very small ones, the corners tend to chill. As normally placed in the ovals both of these deviations affect the extremities of the oval shape and conceivably could do considerable damage. A decided underfilling of the square, as at *B-2*, will cause the bar to turn down in the oval. This in itself is not bad practice except that the controlled section becomes entirely the function of the roller and not of design.



At *C* we see an oval into which a round bar is entered and the above several conditions are reversed. To begin with the comparatively sharp extremities of the oval intended for entry into a square pass as at *B-3* can be considerably blunted for entry into a round pass as at *C-1* and thus retain uniform heat with the rest of the bar. The round section is drafted heaviest at the center ordinates and this shades down to zero drafting at the edges. Keeping roll face friction in mind this creates a lessened amount of spread at the end zones. The application of the drafting to the middle zones in itself creates a greater elongation with a reduced amount of side displacement.

A further advantage of the round process passes lies in the elimination of such twist guides as are necessary when turning the squares into the ovals. Round bars enter the ovals in the same relative position as they were formed, that is, by a straight delivery. In this, however, the round sections must be held to as nearly a circular shape as possible to secure the best results. Sketch *C-2* shows the effect of un underfilled round pass which would tend to turn down in the oval pass. However, if made slightly elliptical as at sketch *C-3* the bar would function very well.

The above creates a general picture perhaps with an emphasis given to the round process passes. Application of either scheme, or any other for that matter, is dependent upon other factors among which are peculiarities of surface quality, whether the scheme is universal to the mill's range of sizes and if more or less roll changing is a consideration. However, all efforts in these matters have as their objectives improvement of the product along with increased efficiency of operation. Neither can be overlooked in existing mills and both must be a major consideration in the design of future mills.

DISCUSSION

PRESENTED BY

J. W. SHEPERDSON, *Vice President*, Morgan Construction Company, Worcester, Massachusetts

R. M. HUSSEY, *Superintendent*, Rod and Wire Mills, Jones and Laughlin Steel Corporation, Aliquippa, Pennsylvania

C. E. JOHNSON, *Superintendent*, Rod and Wire Mills, Bethlehem Steel Company, Sparrows Point, Maryland

LOUIS MOSES, *Superintendent*, Rail Mill and Roll Department, Bethlehem Steel Company, Sparrows Point, Maryland

J. W. SHEPERDSON: Mr. Moses has presented a splendid paper and has given a concise history of rod mills. I think he has sketched admirably the developments in rod rolling from the days of Garrett looping mills through the straight continuous mills with single and multiple drives up to the mill of today, which is a combination mill, primarily to roll rods, and secondarily, to produce round and square merchant products.

Some people believe that a continuous mill is one in which the roll stands are in one continuous straight tandem arrangement. True, that is the purest kind of a continuous mill, but to me a continuous mill is much more than this.

First, I regard a continuous mill to be one in which the product passes but once through each pair of rolls. In other words, the product does not retrace its steps through the same roll stand like in many a 3-high mill. Secondly, in a continuous mill the rolls must have

progressively increasing speeds which will take care of the elongation that is taking place. This I believe is the broad and complete definition of a continuous mill. I don't care how the stands may be arranged, whether in straight continuous formation or offset by means of two, or three, or four loops, as long as the speeds of all the roll stands come within the definition of being speeded to compensate for the elongation. When there is a loop between roll stands which neither grows nor shrinks, it is obviously the same as if these roll stands were arranged in tandem. When, however, arranged for the formation of a loop, one is sure there is freedom of operation because of the visible evidence of this freedom.

I don't care how skillful a roller may be, and there are a great many skillful rollers, the roller and the crew will not permit slack to take place between tandem continuous stands; they will set the mill for a slight pull and this is almost as bad as pulling a lot. Consequently, the product coming out of a tandem continuous mill is not of uniform section throughout. There will be heavy front and back ends if the remainder of the bar is to size.

The object of employing intervening looping stands between a straight continuous roughing mill and a straight continuous finishing mill is to uniformize, if I may be permitted to create such a verb, the section which is being delivered by the continuous roughing mill. In other words, one must present to the finishing mill as uniform a section as it is possible to roll. The looping stands do this, as they do in a merchant mill, and therefore in a rod mill having floor loops, the final rolling of the rod in the last six stands will begin from a uniform bar and the effect of pull will be limited to influence of the last six stands. This is the reason for the improvement in the quality of rods which are rolled in mills not of the straight continuous tandem arrangement.

There is another feature in the mill which grows out of the use of a multiplicity of motors. In former days the mill designer was confronted with the problem of building a mill to receive power from a single source. In the earlier days it was an engine and one had to use a combination of gears and belts to drive all the roll stands in fixed speed relation. Later a single motor took the place of the engine. All corrections in such a mill had to be made solely by roll adjustment. All size changes had to be made in the same way. When large rod sizes had to be rolled, one had to use but a small portion of all the roll stands, omitting several passes near the heating furnace and several passes at the finishing end. Every roller knows that large sizes produced on a closely coupled, fixed speed continuous mill are a nightmare. With the advent of motors possessing close regulation and a wide range of speed adjustment, it is possible now to subdivide a mill into a multiplicity of motor drives. This possesses important advantages.

Take for instance, the group of nine roll stands in the roughing mill. These are driven by three motors. If there were only one motor to drive this group of nine roll stands, the roller would have to depend solely on his skill to adjust these passes to secure coördinate operation. Today, with three motors, the roller has the advantage either of adjusting the speed of some of the stands or of setting the passes, depending upon which will give him the result he is seeking. Sometimes it is not advantageous to adjust the pass, because the section being delivered to the successive pass is just right, yet a pull or push exists. Consequently, the roller will adjust the speed of one or more of the motors, not the sections. He does this himself at the roughing mill by means of a controller located conveniently; he doesn't signal to the pulpit. This, I think, has an important influence on the quality of rods produced by modern rod mills, equipped with several adjustable speed motors.

If a rod mill is to produce nothing else but No. 5 rods, perhaps one could with propriety apply a single motor to such a mill and pound out No. 5 rods. However, who is wise enough to say, that, during the life of a mill, conditions will not change calling for variety in size of product. Depressions are one of these changing conditions and it is then that one attempts to do things on mills for which they are not specifically built, to secure what business there may be available. A mill may be built for a certain purpose and then the question comes up, "Can we roll something else on it?" Circumstances compel policies. If you own a rod mill coupled from end to end to a lone drive and wish to roll a large rod, you have to dummy a certain number of passes at the furnace end and another number of passes at the reel end of the mill, using a small portion of the mill in the middle. With a mill driven by several adjustable speed motors, one can always enter the first pair of rolls and adjust the speed of these rolls to coördinate with what is required to deliver the section at a given point in the mill. The mill at Sparrows Point, becuase of its inherent motor control, rolls No. 5 rods at one extreme of its range and 1⅛ in. rounds at the other. And if you will take your slide rule and compare the areas of a No. 5 rod and a 1⅛ in. round you will discover that this is a range of production seldom found on a single mill.

The mill is being extremely well operated. I was astonished the other day to hear that they had attained 1028 tons in 24 hours. This is a fine performance. During the next 24 hours they rolled 990 tons. A subsequent turn came along and they did not do so well; they dropped to 750 tons; this didn't please the management because they had become quickly accustomed to tonnages of around 1000 tons per day and now insist on this every day.

All of you know that on some days a mill will run into an epidemic of cobbles—the same crew, the same steel, the same mill. A mill has a personality of its own and sometimes acts like a prima donna. These days are vexing to every one.

R. M. HUSSEY: I enjoyed Mr. Moses' paper very much. He got around, in the last part of his paper, to an item that I think is of vital interest—and that is the matter of pass system, whether it is a square or a round pass system—that is, a square-oval-square or round-oval-round—and I would certainly like to hear more on that subject.

One of the troublesome things we have in a rod mill is the matter of quality in the round, for the cold heading trade, and I am beginning to believe, although I haven't had experience with the oval-round-oval system of passes, that probably there are some distinct advantages in that system, conducive to good cold heading

quality. I would certainly like to hear more from Mr. Moses on that subject.

C. E. JOHNSON: Mr. Moses' discussion on rolls brings up the arrangements and combinations of holes, as mill terms the grooves, and as they are cut into the rolls.

The roll shop confers with the mill and order department with regard to how many holes should be provided for each size of rod or rounds in a particular set. Rolls are then prepared according to such a scale of multiple sizes.

It frequently happens that scheduling requirements entail roll changes consuming valuable mill time. Accordingly we will request the roll shop to open up a few holes in a set of rolls so that a miscellaneous combination of sizes of relatively small tonnage can be rolled in one set of rolls.

The mill fully understands the objections of the shop to change their arrangements of grooves because too much of this results in having on hand a supply of rolls which are not much good for anything except for the peculiar purpose they were made for.

In matters of this kind the determining factor is entirely one of cost. The mill realizes that it is impossible to have rolls ready which will in themselves meet a varying lot of sizes at any given time. Occasions will arise, however, when such practice must be adopted.

The mill is told that, aside from the most popular sizes, there is a lot of potential tonnage in a roll face which is not fully used up.

Our practice is to keep the roll department advised on the pending schedule and depend on them to provide the fewest number of roll changes to meet the various requirements so as to best meet these situations. The matter necessarily becomes one of complete coöperation between both parties, each recognizing the other's point of view.

LOUIS MOSES: Mr. Sheperdson has given us a clear definition of the continuous system of rolling. Operators take a great deal for granted in their discussions of varying types of mills and his remarks are both timely and appreciated. I might say that the demands from plants everywhere keep Mr. Sheperdson fully posted at all times on changing trends of the industry, many of which he had anticipated and was ready for prior to being consulted and, aside from this, originating and developing a considerable number himself.

Mr. Hussey desires a further discussion of whatever advantages round process-passes may have over the time honored square-process passes in the rolling of cold-heading and upsetting quality rods. The production of such highly finished material is not an easy matter. Slight surface defects which in no manner would adversely affect the best grades of rods destined for other usage will show up to the point of rejection when cold-heading operations reach some of the proportions demanded by the trade. A head diameter of 1 in. as cold upset from a .214 in. diameter rod is an instance of this, and such proportions may be exeeded for all I know.

To begin with, no system of passes can eliminate a seam which already is in the billet. Secondly, inferior upsetting rod has resulted from almost perfect surfaced billets, made especially for the occasion, through maltreatment accorded by the rod mill.

Theoretically, and to a considerable extent practically, the round pass method offers lessened opportunity for the rolling action to open up the surface of tender surfaced steel. The work itself is better distributed and, in those sizes under consideration, there is little or no difference in the relative angle of bite between the two methods. With ovals made from rounds it has been quite definitely demonstrated that the surface adjacent to the edge is smoother because of the lessened spreading action. As shown by Figure 9 a rather sharp edged oval, necessary for use with squares, is contrasted with blunter edged ovals for entry into a round pass.

An unthinking mill organization will condemn round passes without giving them sufficient trial. Some of the ancient landmarks associated with the use of squares are entirely lacking, especially the "brown" streaks which so greatly serve the roller's eye in his control of bar entry and twists. The blunt edge of the ovals used with round passes and the curved surfaces of the rounds themselves do not present such "cooling" streaks. Therefore an added skill needs to be developed in the matter of holding up the oval and more care necessarily employed in maintaining the round grooves of top and bottom rolls in exact registry with one another.

Of two particular companies in mind, both of whom are making a splendid job of upsetting grades, one uses squares throughout and the other uses the round process. There is mighty little to choose from between the products of each and both satisfy their customers. Similarly, the two mills which you viewed today employ both systems of passes although the finishing of each are equipped with the rounds. Good as well as bad results have been produced from either scheme. A Garrett mill enjoying a deservedly high standing with its products rolls this grade of rod by the square process-passes, which in all essentials correspond to those used in Mr. Hussey's two rod mills.

If a blacksmith undertakes to forge a round from a square piece his manipulation under the hammer faces will consist of turning the bar 90 degrees between each blow. When reduction approaches the desired size of the round he will then work off the corners and finally draw the bar through a swedge. But in a rolling mill why should we go to the trouble of alternately building up square corners, roll them off after each build-up for a final section having no corners, all with the attendant hazards of scratching, malformed corners, and with the differential cooling rates of such corners. Slight variations in temperature create equal, or perhaps greater, differential in elongation properties, which in the same bar can at least be considered as being harmful in effects to the surface skin.

Limitations are presented in the amount of roughing work to be expected with rounds. The oval-square-oval method is perhaps the most rapid means of area reduction. In a period of enthusiasm the No. 2 mill was equipped with round passes but disappointing results in this respect were had. With the respective areas of each stand nearly equal to those of the square system of passes it was found that the roughing stands needed to be much smaller in area. With the square pass scheme a 2½ in. billet can be reduced to a No. 5 rod but with the "round" rolls a No. 4½ rod was barely possible with a 2 in. billet. Necessarily tabled for the

(*Please turn to page 58.*)

TABULATION OF BEARINGS FOR BRIDGE AND TROLLEY TRACK WHEEL AXLES

LOADS GIVEN BELOW ARE BOX LOADS

FOR WHEEL LOADS DOUBLE THIS AMOUNT

CLASS No. 1
68,000 HRS. MIN. LIFE
COIL STORAGE
STOCK YARD
SLAB HANDLING
SKULL CRACKER
FINISHING AND SHIPPING

CLASS No. 2
50,000 HRS. MIN. LIFE
LADLE CRANE
CHARGING MACHINE
SOAKING PIT

CLASS No. 3
40,000 HRS. MIN. LIFE
ROLL SHOP
STRIPPER

CLASS No. 4
35,000 HRS. MIN. LIFE
MILL SERVICE CRANE
MOULD YARD
COLD STRIP MILL

LOAD PER BOX IN POUNDS	MAKE OF BEARING	WHEEL BORE	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.
1,000	HYATT	1.5748"	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS	R-3208-TS
	ROLLWAY	1.5748"	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208	D-208
	SKF	1.5748"	2/308	2/308	2/308	2/308	2/308	2/308	2/308	2/308	2/308	2/308	2/308	2/308
	TIMKEN	1⅝"	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284
	TYSON							Note: Bearing not Available at Present						
	NORMA-HOFFMANN	1.5748"	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L	R-160-L
3,000	HYATT	1.7717"	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS
	ROLLWAY	1.7717"	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309	D-309
	SKF	1.7717"	2/309	2/309	22309	2/309	2/309	22309	2/309	2/309	2/309	2/309	2/309	2/309
	TIMKEN	1¾"	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326
	TYSON							Note: Bearing not Available at Present						
	NORMA-HOFFMANN	1.7717"	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L	R-145-L
5,000	HYATT	2.1654"	A-5311-TS	A-5311-TS	A-5311-TS	A-5211-TS	A-5311-TS	A-5311-TS	A-5211-TS	A-5211-TS	A-5311-TS	A-5211-TS	A-5211-TS	A-5311-TS
	ROLLWAY	2.1654"	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311	D-311
	SKF	2.1654"	2/311	22311	22311	2/311	22311	22311	2/311	22311	22311	2/311	2/311	22311
	TIMKEN	2⅝"	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622	28680-28622
	TYSON							Note: Bearing not Available at Present						
	NORMA-HOFFMANN	2.1654"	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L	R-355-L
7,000	HYATT	2.5591"	A-5313-TS	A-5313-TS	A-5313-TS	A-5213-TS	A-5313-TS	A-5313-TS	A-5213-TS	A-5213-TS	A-5313-TS	A-5213-TS	A-5213-TS	A-5313-TS
	ROLLWAY	2.5591"	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313	D-313
	SKF	2.5591"	2/313	22313	22313	2/313	22313	22313	2/313	22313	22313	2/313	2/313	22313
	TIMKEN	2⅞"	479-472-A	479-472-A	560-552A	479-472A	479-472-A	560-552-A	479-472-A	479-472A	560-552A	3994-3920	3994-3920	479-472A
	TYSON	2⅞"	3984-3920	3984-3920	494N-493	3984-3920	3984-3920	479-472	3984-3920	3984-3920	3984-3920	3984-3920	3984-3920	3984-3920
	NORMA-HOFFMANN	2.5591"	R-305-L	R-305-L	R-305-L	R-105-L	R-306-L	R-305-L	R-105-L	R-305-L	R-305-L	R-105-L	R-305-L	R-305-L
9,000	HYATT	2.9528	A-5315-TS	A-5315-TS	A-5315-TS	A-5215-TS	A-5315-TS	A-5315-TS	A-5215-TS	A-5215-TS	A-5315-TS	A-5215-TS	A-5215-TS	A-5315-TS
	ROLLWAY	2.9528	D-315	D-315	D-315	D-315	D-315	D-315	D-316	D-315	D-315	D-315	D-315	D-316
	SKF	2.9528	2/315	22315	22315	2/315	22315	22315	2/315	22315	22315	2/315	2/315	22315
	TIMKEN	3"	47680-47620	47680-47620	575-572	47680-47620	47680-47620	575-572	47680-47620	47680-47620	575-572	4984-493	4984-493	47680-47620
	TYSON	3"	495-A-493	575-572	575-572	495-A-493	495-A-493	575-572	495-A-493	4984-493	575-572	495-A-493	495-A-493	575-572
	NORMA-HOFFMANN	2.9528	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L	R-375-L
10,000	HYATT	3.1496	A-5316-TS	A-5316-TS	A-5316-TS	A-5216-TS	A-5316-TS	A-5316-TS	A-5216-TS	A-5216-TS	A-5316-TS	A-5216-TS	A-5216-TS	A-5316-TS
	ROLLWAY	3.1496	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316	D-316
	SKF	3.1496	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316	22316
	TIMKEN	3¼"	580-572	580-572	595-592-A	580-572	580-572	595-592-A	580-572	580-572	595-592A	495-493	495-493	580-572
	TYSON	3¼"	495-493	580-572	595-592-A	495-493	580-572	580-572	495-493	580-572	580-572	495-493	495-493	580-572
	NORMA-HOFFMANN	3.1496"	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L	R-380-L
12,000	HYATT	3.5433"	A-5218-TS	A-5218-TS	A-5318-TS	A-5218-TS	A-5218-TS	A-5218 TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS
	ROLLWAY	3.5433"	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65	D-218-65
	SKF	3.5433"	22318	22318	22318	22318	22318	22318	22318	22318	22318	22218	22318	22318
	TIMKEN	3½"	593-592-A	593-592-A	679-672	593-592-A	593-592-A	679-672	593-592-A	593-592A	679-672	593-592A	593-592	593-592A
	TYSON	3½"	593-592-A	593-592-A	679-672	593-592-A	593-592-A	679-672	593-592-A	593-592A	679-672	593-592-A	593-592	593-592-A
	NORMA-HOFFMANN	3.5433"	R-390-L	R-390-L	R-390-L	R-390-L	R-390-L	R-390-L	R-390-L	R-390-L	R-390-L	R-190-L	R-390-L	R-390-L
15,000	HYATT	3.7402"	A-5219-TS	A-5219-TS	A-5319-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS
	ROLLWAY	3.7402"	D-319	D-319	D-319	D 319	D-319	D-319	D-319	D-319	D-319	D-319	D-319	D-319
	SKF	3.7402"	22319	22319	22319	22319	22319	22319	22319	22319	22319	22319	22319	22319
	TIMKEN	3¾"	683-672	683-672	777-772	683-672	683-672	777-772	683-672	683-672	777-772	594-592A	594-592	683-672
	TYSON	3¾"	683-672	683-672	776-772	594-592-A	683-672	776-772	594-592-A	683-672	776-772	594-592-A	683-672	683-672
	NORMA-HOFFMANN	3.7402"	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L	R-395-L
18,000	HYATT	3.9370	A-5220-TS	A-5320-TS	A-5220-TS	A-5220-TS	A-5320-TS	A-5320-TS	A-5220-TS	A-5220-TS	A-5320-TS	A-5220-TS	A-5220-TS	A-5220-TS
	ROLLWAY	3.9370	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320	D-320
	SKF	3.9370	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320
	TIMKEN	4"	780-772	780-772	861-854	780-772	780-772	861-854	780-772	780-772	861-854	687-672	687-672	780-772
	TYSON	4"	687-672	780-772	780-772	687-672	780-772	780-772	687-672	780-772	780-772	52400-52618	780-772	780-772
	NORMA-HOFFMANN	3.9370	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L
20,000	HYATT	3.9370	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS
	ROLLWAY	3.9370	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220	C-5-5220
	SKF	3.9370	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320	22320
	TIMKEN	4 11/16 & 4 23/32	71425-71750 A	71425-7175 A	936-932 A	71425-71750 A	71425-71750 A	936-932 A	71428-71750 A	71428-71750 A	71425-7175 A	71425-71750A	71425-71750	71425-71750 A
	TYSON	4¼"	71425-71750	71425-71750	936-932	71425-71750	71425-71750 A	936-932	71428-71750	71428-71750	71425-71750	71425-71750	71425-71750	71425-71750
	NORMA-HOFFMANN	3.9370	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L	R-400-L
24,000	HYATT	4.3307"	A-5322-TS	A-5322-TS	A-5322-TS	A-5222-TS	A-5322-TS	A-5322-TS	A-5222-TS	A-5222-TS	A-5322-TS	A-5222-TS	A-5222-TS	A-5322-TS
	ROLLWAY	4.3307"	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222	C-5-5222
	SKF	4.3307"	22322	22322	22322	22322	22322	22322	22322	22322	22322	22322	22322	22322
	TIMKEN	4½"	938-932	938-932	938-932	938-932	938-932	938-932	938-932	938-932	938-932	71450-71750	71450-71750	938-932
	TYSON	4½"	71450-71750	938-932	938-932	71450-71750	938-932	938-932	71450-71750	71450-71750	938-932	71450-71750	71450-71750	938-932
	NORMA-HOFFMANN	4.3307"	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L	R-410-L
30,000	HYATT	4.7244	A-5324-TS	A-5324-TS	A-5324-TS	A-5324-TS	A-5324-TS	A-5324-TS	A-5224-TS	A-5324-TS	A-5324-TS	A-5224-TS	A-5324-TS	A-5324-TS
	ROLLWAY	4.7244	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224	C-5-5224
	SKF	4.7244	22324	22324	22324	22324	22324	22324	22324	22324	22324	22324	22324	22324
	TIMKEN	5"	95500-95925	95500-95925	EE 153050-153100	95500-95925	95500-95925	EE 153050-153100	95500-95925	95500-95925	EE 153050-153100	67388-67320	67388-67320	95500-95925
	TYSON	5"	895N-892	895N-892	95500-95925	74500-74850	895N-892	95500-95925	790N-792	895N-892	895N-892	790N-792	895N-892	895N-892
	NORMA-HOFFMANN	4.7244	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L	R-420-L
40,000	HYATT	6.2992"	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS
	ROLLWAY	5.5118"	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228	C-5-5228
	SKF	5.5118"	22328	22328	22328	22328	22328	22328	22328	22328	22328	22328	22328	22328
	TIMKEN	5¾"	99575-99100	99575-99100	EE-107057-107105	99575-99100	99575-99100	EE 107057-107105	99575-99100	99575-99100	EE-107057-107105	99575-99100	99575-99100	EE 107057-107105
	TYSON	5¾"	99575-99100	154058X-154107N	155756X-158/12N	99575-99100	99575-99100	154058N-154107N	99575-99100	99575-99100	154058N-154107	99575-99100	99575-99100	154058N-154107N
	NORMA-HOFFMANN	5.5118"	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A	R-440-L-A
50,000	HYATT	6.6929"	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS
	ROLLWAY	6.1992"	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232	C-5-5232
	SKF	6.1992"	22332	22332	22332	22332	22332	22332	22332	22332	22332	22332	22332	22332
	TIMKEN	6½"	94649-94113	94649-94113	EE 219065-219122	94649-94113	94649-94113	EE 219065-219122	94649-94113	94649-94113	EE 219065-219122	94649-94113	94649-94113	EE-219065-219122
	TYSON	6½"	94649-94113	58650N-158/12N	47006SN-47013S	94649-94113	158650N-158/12N	47006SN-47013S	94649-94113	158650N-158/12N	158650N-158/12N	94649-94113	94649-94113	158650N-158/12N
	NORMA-HOFFMANN	-	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)
60,000	HYATT	7.4803"	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS
	ROLLWAY	7.4803"	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238	C-5-5238
	SKF	7.4803"	22338	22338	22338	22338	22338	22338	22338	22338	22338	22338	22338	22338
	TIMKEN	8⅛ & 7½	NP 122075-122126 A	NP 122075-122126 A	EE 420751-421437 A	122075N-122126 A	NP 122075-122126 A	EE 420751-421437 A	NP 122075-122126 A	NP 122075-122126 A	EE 420751-421437 A	NP 122075-122126 A	NP 122075-122126 A	EE 420751-421437
	TYSON	7½	122075N-122126	122075N-122126	420751N-421437	122075N-122126	122075N-122126	420751N-421437	93750-93125	122075N-122126	122075N-122126	93750-93125	122075N-122126	122075N-122126
	NORMA-HOFFMANN	-	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)		RMS-25-L (6" BORE)	RMS-25-L (6" BORE)		RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)	RMS-25-L (6" BORE)
70,000	HYATT	7.8740"	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS
	ROLLWAY	7.8740"	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240	C-5-5240
	SKF	7.8740"	23140	23240	22340	22340	22340	22340	22340	22340	22340	22340	22340	22340
	TIMKEN	8"	EE 420801-421437	EE 420801-421437	EE-420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437
	TYSON	8"	420801-421437	430800-N-431875	430800-N-431875	420801-421437	420801-421437	430800N-431875	420801-421437	420801-421437	430800N-431875	420801-421437	420801-421437	420801-421437
	NORMA-HOFFMANN	-	RMS-27-L (9" BORE)			RMS-26-L (8" BORE)	RMS-27-L (9" BORE)		RMS-26-L (8" BORE)	RMS-27-L (9" BORE)	RMS-27-L (9" BORE)	RMS-26-L (8" BORE)		RMS-27-L (9" BORE)
80,000	HYATT							Note: Bearing not Available at Present						
	ROLLWAY	8.6614"	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244	C-5-5244
	SKF	8.6614"	23244	23244	22344	23144	22344	22344	23144	23244	22344	23144	23144	23144
	TIMKEN	9"	EE 430900-431575	EE 430900-431575	EE 770091-770167	EE 430900-431575	EE 430900-431575	EE 770091-770167	EE 430900-431575	EE 430900-431575	EE 770091-770167	EE 430900-431575	EE 430900-431575	EE 430900-431575
	TYSON	9"	430900-431575	923090N-923175	923090N-923175	430900-431575	430900-431575	923090N-923175	430900-431575	430900-431575	923090N-923175	430900-431575	430900-431575	430900-431575
	NORMA-HOFFMANN		RMS-28-L (9" BORE)			RMS-27-L (9" BORE)			RMS-27-L (9" BORE)				RMS-27-L (9" BORE)	RMS-27-L (9" BORE)
90,000	HYATT							Note: Bearing not Available at Present						
	ROLLWAY	9.4488"	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248
	SKF	9.4488"	23248	23248	22348	23148	23248	22348	23148	23248	22348	23148	23148	23148
	TIMKEN	9½"	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175
	TYSON	9½"	430950N-431575	923095-923175	295950-295193	430950N-431575	923095-923175	295950-295193	430950N-431575	923095-923175	323095-323175	430950N-431575	923095-923175	923095-923175
	NORMA-HOFFMANN	10"				RMS-28-L						RMS-28-L		
100,000	HYATT							Note: Bearing not Available at Present						
	ROLLWAY	9.4488"	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248	C-5-5248
	SKF	9.4488"	23248	23248	22348 (ok'd)	23248	23248	23252 (ok'd)	23248	23248	22348	23148	23248	23248
	TIMKEN	9½"	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175
	TYSON	9½"	923095-923175	295950-295193	295950-295193	923095-923175	923095-923175	295950-295193	430950N-431575	923095-923175	295950-295193	430950N-431575	923095-923175	923095-923175
	NORMA-HOFFMANN	10"										RMS-28-L		

MINIMUM LIFE OF HOURS BASED ON 10% FAILU

Anti-friction Bearings

The accompanying tabulation is a portion of the report of the Sub-Committee on Bearings of the A.I.S.E. Crane Specifications Committee. This Sub-Committee is composed of H. W. Neblett, Inland Steel Company, H. W. Ball, Morgan Engineering Company, and R. N. Thompson, Great Lakes Steel Corporation.

Full size prints of this tabulation are available from the Association headquarters at a cost of one dollar to cover printing and mailing.

In 1938 the Association of Iron and Steel Engineers decided to revise and re-write their standard crane specifications to provide a specification that conformed with present-day practice and the general advancements in the art of crane building that had materialized since the original crane specifications were adopted.

A crane specification committee was appointed consisting of representatives from the various steel companies and the crane builders. This committee started work in 1939 and it was thought that the revision was of such magnitude and scope that best results could be obtained if sub-committees were formed to pursue particular sections of these specifications, each subcommittee being a part of and reporting to the crane specifications committee.

One of these section committees is the Sub-Committee on Bearings. Among the subjects investigated by this committee was anti-friction bearings for crane trolley and bridge track wheel axles for the purpose of determining the proper bearings for cranes in the various types of mill service. Bearing sizes are affected by the speed, load and length of service or hours operating life expected. The speed is a variable determined by the operating requirements of the crane. Load is determined by the weight of the crane and its lifting capacity. Operating hours are directly dependent upon the service requirements of cranes in their respective departments of the steel plant. Due to the presence of all these variables, each directly affecting the bearings, it was decided the most plausible way to present this information for general use would be in the form of tabulated data that would include this information for all types of crane service.

With these factors in mind, a tabulation was made giving the box or bearing load in pounds, the speed in rpm. and length of service required for the various crane applications in hours operating life. The hours operating life was determined from test data and operating records from cranes in service in the several departments of various steel plants. It was found the service requirements in the various departments of the steel plants fell into six classifications. For example, a crane in the finishing and shipping department was found to operate 6500 hours in a year while a crane in a motor room would operate a total of 800 hours in a year, other departments and services falling at various points between these two extremes. On this basis, the six classifications and the hours operating per year for each classification was determined. It was decided by the committee that bearings on cranes should have a minimum operating life of 10 years. Consequently, the yearly hours operation for each class of crane service was multiplied by 10 to determine the minimum hours operating life. This means that 10 years should elapse before the first bearing fails, and that average life should be 5 times this figure.

A tabulation sheet was made up showing the six classifications; the hours of operation for each crane,

(*Please turn to page 58.*)

	CLASS No. 5 — 25,000 HRS. MIN. LIFE — MACHINE SHOP				CLASS No. 6 — 8,000 HRS. MIN. LIFE — POWER HOUSE, MOTOR ROOM, INDUSTRIAL CRANES			
	61 TO 100 R.P.M.	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.	1 TO 30 R.P.M.	31 TO 60 R.P.M.	61 TO 100 R.P.M.	
	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	A-5208-TS	
	D-208	D-208	D-208	D-208	D-208	D-208	D-208	
	21308	21308	21308	21308	21308	21308	21308	
	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	16150-16284	
	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	E-140-L	
	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	A-5209-TS	
	D-309	D-309	D-309	D-309	D-309	D-309	D-309	
	21309	21309	21309	21309	21309	21309	21309	
	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	35175-35326	
	E-345-L	E-145-L	E-145-L	E-345-L	E-145-L	E-145-L	E-145-L	
	A-5311-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	A-5211-TS	
	D-311	D-311	D-311	D-311	D-311	D-311	D-311	
	22311	21311	21311	22311	21311	21311	21311	
	28680-28822	28680-28822	28680-28822	28680-28822	28680-28822	28680-28822	28680-28822	
	E-355-L	E-155-L	E-355-L	E-355-L	E-155-L	E-155-L	E-155-L	
	A-5313-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	A-5213-TS	
	D-313	D-313	D-313	D-313	D-313	D-313	D-313	
	22313	21313	21313	22313	21313	21313	21313	
	479-472A	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	3994-3920	
	3984-3920	396A-394A	3984-3920	3984-3920	396A-394A	396A-394A	396A-394A	
	E-365-L	E-165-L	E-165-L	E-365-L	E-165-L	E-165-L	E-195-L	
	A-5315-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	A-5215-TS	
	D-315	D-315	D-315	D-315	D-315	D-315	D-315	
	22315	21315	21315	22315	21315	21315	21315	
	47080-47920	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493	
	575-572	495A-493	495A-493	495A-493	495A-493	495A-493	495A-493	
	E-375-L	E-175-L	E-375-L	E-375-L	E-175-L	E-175-L	E-175-L	
	A-5316-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	A-5216-TS	
	D-316	D-316	D-316	D-316	D-316	D-316	D-316	
	22316	22316	22316	22316	22216	22216	22316	
	580-572	495-493	495-493	580-572	495-493	495-493	495-493	
	580-572	495-493	495-493	580-572	495-493	495-493	495-493	
	E-380-L	E-380-L	E-380-L	E-380-L	E-180-L	E-180-L	E-180-L	
	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	A-5218-TS	
	D-218-45	D-218-45	D-218-45	D-218-45	D-218-45	D-218-45	D-218-45	
	22318	22218	22318	22318	22218	22218	22218	
	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	
	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	593-592A	
	E-390-L	E-190-L	E-390-L	E-390-L	E-190-L	E-190-L	E-190-L	
	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	A-5219-TS	
	D-319	D-319	D-319	D-319	D-319	D-319	D-319	
	22319	22219	22319	22319	22219	22219	22219	
	683-672	594-592A	594-592A	683-672	594-592A	594-592A	594-592A	
	683-672	594-592A	594-592A	683-672	594-592A	594-592A	594-592A	
	E-395-L	E-195-L	E-395-L	E-395-L	E-195-L	E-195-L	E-195-L	
	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	A-5220-TS	
	D-320	D-320	D-320	D-320	D-320	D-320	D-320	
	22320	22220	22320	22320	22220	22220	22220	
	780-772	687-672	687-672	780-772	687-672	687-672	687-672	
	780-772	52400-52618	687-672	780-772	52400-52618	52400-52618	52400-52618	
	E-400-L	E-400-L	E-400-L	E-400-L	E-200-L	E-200-L	E-200-L	
	A-5320-TS	A-5320-TS	A-5320-TS	A-5320-TS	A-5220-TS	A-5220-TS	A-5220-TS	
	CS-5220	CS-5220	CS-5220	CS-5220	CS-5220	CS-6220	CS-5220	
	22320	22320	22320	22320	22220	22220	22320	
	71425-71750A	64433-64700B	64433-64700B	71425-71750A	64433-64700B	64433-64700B	64433-64700B	
	71425-71750	71425-71750	71425-71750	71425-71750	71425-71750	71425-71750	71425-71750	
	E-400-L	E-400-L	E-400-L	E-400-L	E-200-L	E-200-L	E-400-L	
	A-5322-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	A-5222-TS	
	CS-5222	CS-5222	CS-5222	CS-5222	CS-5222	CS-5222	CS-5222	
	22322	22322	22322	22322	22222	22222	22322	
	938-932	71450-71750	71450-71750	71450-71750	64450-64700	64450-64700	71450-71750	
	938-932	71450-71750	71450-71750	71450-71750	71450-71750	71450-71750	71450-71750	
	E-410-L	E-410-L	E-410-L	E-410-L	E-210-L	E-210-L	E-410-L	
	A-5324-TS	A-5224-TS	A-5224-TS	A-5224-TS	A-5224-TS	A-5224-TS	A-5224-TS	
	CS-5224	CS-5224	CS-5224	CS-5224	CS-5224	CS-5224	CS-5224	
	22324	22324	22324	22324	22224	22224	22324	
	95500-95925	67388-67320	67388-67320	95500-95925	67388-67320	67388-67320	67388-67320	
	895N-892	796N-792	895N-892	895N-892	796N-792	796N-792	796N-792	
	E-420-L	E-420-L	E-420-L	E-420-L	E-220-L-A	E-220-L-A	E-420-L	
	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	A-5232-TS	
	CS-5228	CS-5228	CS-5228	CS-5228	CS-5228	CS-5228	CS-5228	
	22328	22228	22328	22328	22228	22228	22328	
	EE 107187-107105	82570-82950	82570-82950	99875-99100	82570-82950	82570-82950	82570-82950	
	164088N-164107N	99575-99100	99575-99100	99575-99100	81578-81962	81578-81962	99575-99100	
	E-440-L-A	E-440-L-A	E-440-L-A	E-440-L-A	E-220-L-A	E-440-L-A	E-440-L-A	
	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	A-5234-TS	
	CS-5232	CS-5232	CS-5232	CS-5232	CS-5232	CS-5232	CS-5232	
	22332	22232	22332	22332	22232	22232	22232	
	EE 2190651-219122	94649-94113	94649-94113	EE 2190651-219122	94649-94113	94649-94113	94649-94113	
	158650N-158121N	94649-94113	94649-94113	158650N-158121N	89650N-89150N	89650N-89150N	94649-94113	
	(1¾" BORE)	RMS-24-L (6¾" BORE)	RMS-24-L (6¾" BORE)	(1¾" BORE)	(6¾" BORE)	RMS-24-L (6¾" BORE)	RMS-24-L (6¾" BORE)	
	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	A-5238-TS	
	CS-5238	CS-5238	CS-5238	CS-5238	CS-5238	CS-5238	CS-5238	
	22338	22238	22338	22338	22238	22238	22238	
	EE 420781-421437	93750-93125A	93750-93125A	AA 2220TS-222120A	93750-93125A	93750-93125A	93750-93125A	
	222070N-222126	93750-93125	222070N-222126	222070N-222126	93750-93125	93750-93125	93750-93125	
	(1¾" BORE)	RMS-28-L (1¾" BORE)	RMS-28-L (1¾" BORE)	(1¾" BORE)	(1¾" BORE)	RMS-28-L (1¾" BORE)	RMS-28-L (1¾" BORE)	
	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	A-5240-TS	
	CS-5240	CS-5240	CS-5240	CS-5240	CS-5240	CS-5240	CS-5240	
	22340	22240	22340	22340	22240	22240	22240	
	EE 420801-421437	EE 420801-421437	EE 420801-421437	EE 420801-421437	93800-93125	93800-93125	93800-93125	
	420801-421437	93800-93125	420801-421437	420801-421437	93800-93125	93800-93125	93800-93125	
	(3" BORE)	RMS-28-L (3" BORE)	(3" BORE)	RMS-28-L (3" BORE)	(3" BORE)	RMS-28-L (3" BORE)	(3" BORE)	RMS-28-L (3" BORE)
	CS-5244	CS-5244	CS-5244	CS-5244	CS-5244	CS-5244	CS-5244	
	23244	23144	23144	22344	23144	23144	23144	
	EE 430900-431575	EE 430900-431575	EE 430900-431575	EE 430900-431575	96900-96140	96900-96140	96900-96140	
	430900-431575	430900-431575	430900-431575	430900-431575	8570N-8520	96900-96140	96900-96140	
		(3" BORE)	RMS-28-L (3" BORE)	(3" BORE)	(3" BORE)	RMS-28-L (3" BORE)	RMS-28-L (3" BORE)	
	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	
	23248	23148	23248	23248	23148	23148	23148	
	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 125095-125145	EE 125095-125145	EE 125095-125145	
	923095-923175	430950N-431575	430950N-431575	923095-923175	125095-125145	430950N-431575	430950N-431575	
			RMS-28-L		RMS-28-L	RMS-28-L	RMS-28-L	
	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	CS-5248	
	23248	23148	23248	23248	23148	23148	23148	
	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 923095-923175	EE 125095-125145	EE 125095-125145	EE 125095-125145	
	196950-295193	430950N-431575	430950N-431575	923095-923175	430950N-431575	430950N-431575	430950N-431575	
		RMS-28-L			RMS-28-L	RMS-28-L	RMS-28-L	

530641

BUILDING UP and HA

in the Steel Plant

By L.
Applied
AIR REDU
PITTSBURG

Presented before A. I. S. E.
ANNUAL CONVENTION, CHICAGO, ILLINOIS,
SEPTEMBER 24-27, 1940

▲ IN recent years, the steel industry has had to seize every opportunity to cut operating costs. At the same time, it has been necessary to maintain production schedules and turn out quality products. In steel mills, failures of machine parts frequently occur, due to fatigue or wear, without notice. The maintenance department then may be confronted with the time element as well as the cost of making repairs or furnishing replacements.

Often repairs can be made in place by welding. Building up broken gear teeth or worn sections of machinery without a great deal of dismantling is common practice. This makes it possible to save time and labor. In some instances the shut down of an entire department can be averted.

Building-up and hard-facing represent major factors in the welding process for the maintenance man, due to their wide range of application, versatility, and the time and expense saved by their use. Many thousands of dollars worth of worn machine and mill parts are salvaged annually through the medium of building-up and hard-facing. In the past few years this method of reclamation of parts has been on the increase, and has established itself as one of the most necessary and forward steps in the maintenance of a modern steel plant.

The advantage of building-up worn sections of machinery with a material superior to that of the original was soon recognized by both the management and department heads in steel mills. As a result, today not only worn sections are built up and hard-faced; but many new parts are undercut and hard-faced with a suitable material before being placed in service. It is now an established fact that parts which have been hard-faced with the proper material will give greater efficiency, last longer, require fewer changes and make it possible to reduce stocks of parts generally kept on hand for replacements. Whether or not to hard-face after building-up depends on the analysis of the base metal, economy, and type of work involved.

PROCESSES EMPLOYED

There are three general processes employed for this phase of welding; namely, oxy-acetylene, metallic arc and carbon arc. Each process has its field and should be chosen for its merits and economy.

Sometimes, parts are hard-faced with the right type of hard-facing material, but are unsatisfactory for service due to the improper selection of the process for the overlay. Although hard-facing materials can be applied with all of the standard methods, certain factors determine the choice of process, for application.

We will try to roughly outline some of the advantages for the forementioned processes.

The oxy-acetylene torch has no substitute when applying manganese bronze to worn sections of malleable or cast iron parts or when building-up cast iron with cast iron filler material. It is also generally used for building-up non-ferrous materials.

The torch allows the operator accurate control of the rate of metal deposit, thickness and smoothness of the overlay. Blow-holes can be eliminated and foreign particles such as rust, scale or dirt readily floated to the surface, sometimes with the aid of flux. Control of the degree of penetration is possible, which is important when using non-ferrous materials as an overlay that should be sweated on. This prevents inter-alloying with the base metal, and the deposited overlay will then retain its hardness and natural characteristics.

Figure 1—Piston from blooming mill engine, 36 in. diameter, was built up $\frac{5}{16}$ in. on diameter, requiring 90 lb. of bronze and 24 hr. time.

Certain classes of hard-facing materials require puddling. Here too, the operator can regulate the depth of penetration at will. Corners and sharp edges can be hard-faced and built-up smoothly without difficulty, thus reducing the grinding and labor costs for finishing. Small parts generally can be preheated with a torch prior to welding, reducing rejects due to checking.

The metallic arc is the most widely used method for welding in the steel plants. Speed of metal deposit, economy of operation, wide selection of rod analysis and

HARD FACING

By L. Ames, Supervisor
Applied Engineering Dept.
AIR REDUCTION SALES COMPANY
PITTSBURGH, PENNA.

flexibility are all in its favor. It has its advantages in control of heat which on machinery, with both heavy and light sections may otherwise cause warpage and set up undue stresses. It allows an operator to weld in confined areas and on heavy machine sections, which is not possible with other methods. The field is so large and the advantages are so evident that time does not permit enumeration of all the possible advantages or applications.

Although the carbon arc is used to a lesser degree than the other processes, it nevertheless has its place in the steel industry, and is used for many applications. There is considerable overlapping of processes where it can be used successfully and economically where the other processes might prove too slow or costly. Some examples are: filling holes in copper chill moulds from induction furnaces; filling sand holes in steel castings; building-up badly worn cast iron wobbler ends; copper welding of heavy sections. The welding foreman generally decides what method is most suitable for the particular operation involved.

SELECTION OF MATERIAL

The question generally arises: What type of material is most suitable to use for building-up? A good rule to follow is to use a rod similar in analysis to that of the base metal. If the base metal is soft and subject to abrasion and impact, then a material should be used that will give greater support or stiffness, and also act as a good base for the overlay. Medium carbon or low alloy steels can generally be used for this purpose.

New rods for the various processes are constantly being developed, so that it is now possible to obtain suitable welding rod material to meet nearly any requirement. High-strength bronzes, corrosion-resisting bronzes, alloy cast irons, alloy steels, high-tensile steels, various types of facing materials with resistance to impact, abrasion, corrosion, or with the properties to retain hardness at elevated temperatures, all lend themselves readily to application with any of the above-mentioned welding processes.

Most of the literature on purposes and applications of various welding rods is pretty reliable and can generally be used to advantage if interpreted correctly. No one type of material for building-up or hard-facing can or will be found suitable for the hundreds of applications and conditions which are encountered in a steel plant. The conditions under which the part works should first be thoroughly studied before selecting a material.

RECLAMATION OF PISTON HEADS

Although a great many steel and cast iron parts are reclaimed with like materials, bronze is used for building-up many parts which are not subjected to abrasion, or are lubricated when sliding action takes place. Reclaiming worn piston heads by building-up with manganese bronze is a successful operation of long standing among the railroads, and is rapidly being adopted by the steel mills as standard practice. When done correctly it is economical, and increases the wearing life of the piston over the original. For this particular operation the oxy-acetylene process is the one most suitable. In the past year, in one mill alone, over 80 piston heads ranging in size from 8 to 54 in. in diameter have been built up in this manner with excellent results.

The piston is prepared for brazing by thoroughly cleaning the surface of oil or grease. If of cast iron, it is sometimes advisable to either grind or sand blast the surface before any bronze is applied. It is then mounted on rollers, so it can be rotated easily and is preheated evenly from 400 to 600 degrees F., the worn area which is usually two-thirds of the circumference of the piston, is marked, and the brazing operation started. The cost of reclaiming depends on the size of the piston and amount of metal required to bring it back to its original size.

Figure 1 shows a piston from a 48 in. blooming mill engine. It is 36 in. in diameter and was built-up 5/16 in. on the diameter. Two of these pistons were reclaimed at the same time. Welding required 24 hours for depositing 90 lb. of bronze to each head. The pistons were machined to size and have now been in service for some time.

RECLAMATION OF GEARS

Although building-up worn or broken gear teeth is not new, time and money often can be saved by using the proper method. On large gears having a heavy rim and large gear teeth it is sometimes practical to stud and arc weld around the studs. However, on small gears or gears with teeth of not larger than 2 or 3 diametral pitch, which are made of cast iron, it is generally more economical and practical to build-up worn or broken teeth with bronze or cast iron. In one case an attempt was made to replace the broken teeth in a cast iron gear

by studding and arc welding around the studs. It failed after a very short time in service. The teeth were too small and the rim too thin to allow proper anchorage of the studs. It was repaired by bronze welding and put back in service in 5 hours.

MILL GUIDES

Mill guides have been a source of trouble in the steel industry for some time because they wear and scratch the steel passing through them in the process of manufacture. The solution to the wearing problem appears simple, at first thought. It would seem that, in order to increase the wearing life of the guides, all that is necessary is to increase the hardness of the guide material. However, in actual practice this does not work out. On tests conducted in the various steel mills, it was generally found that the scratching of steel would increase in proportion to the increase in hardness of the guide material. This condition varied in the different steel mills, with the type of material rolled. Chilled

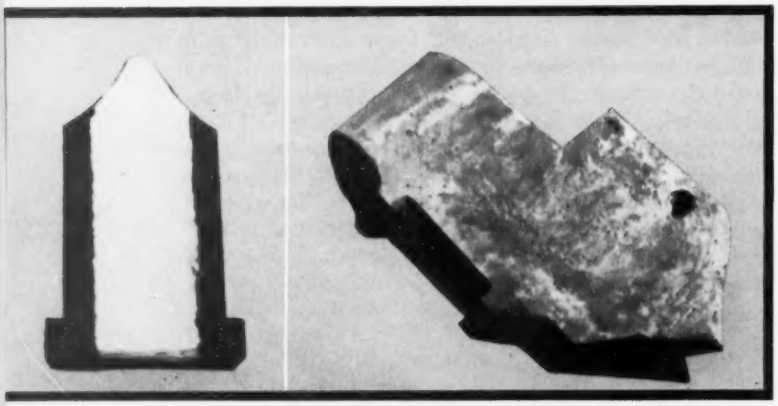


Figure 2—Mill guides may be cut to shape on an automatic cutting machine from carbon steel plate, and hard-faced on both sides. *(Right)*

Figure 3—A ¼ in. layer of cast iron is applied to this cast steel guide. After grinding, the cast iron is flame-hardened. *(Left)*

cast iron guides would give excellent service in one mill, while another mill would be compelled to use guides of very soft iron. Even then the metal would build-up on the guide and cause scratching of the rolled steel. In one case we received permission to hard-face several guides for a bar mill which was using chilled iron guides. Cast iron guides were hard-faced with varied results. Our chief difficulties were breakage in service after hard-facing, and checking of the overlay material on cooling. Further tests were made and the following procedure found to produce satisfactory results.

The guide, shown in Figure 2, is cut out to shape on an automatic cutting machine, from 0.35 to 0.45 per cent carbon steel plate in 1 in. to 1½ in. in thickness. A groove ⅛ in. in depth and 2 in. in width is machined on each side of the guide. The guide is then preheated to about 1100 degrees F. in a gas furnace and hard-faced at that temperature. Both sides are hard-faced with a torch. The hard-facing material is built-up

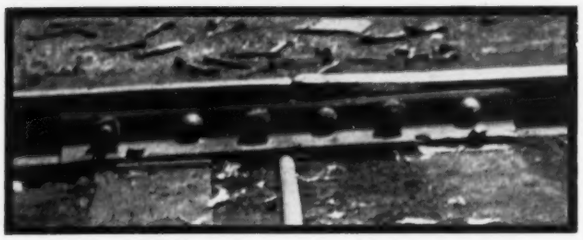


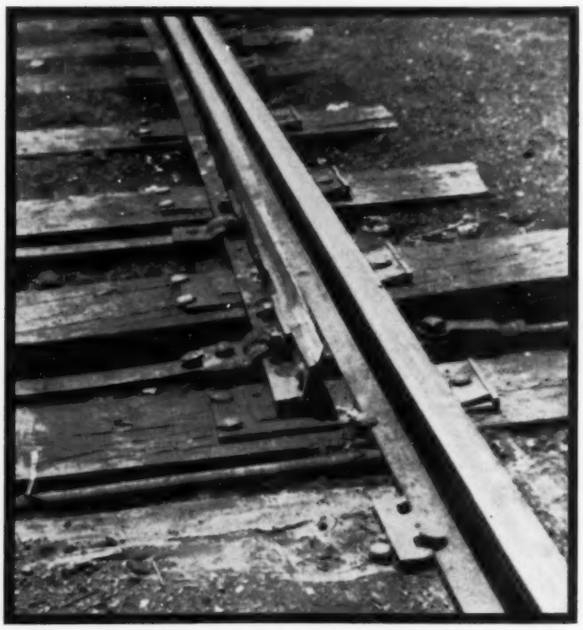
Figure 4—View showing low rail end built up to height of higher rail to reduce impact.

Figure 5—Battered rail joints may also be built up with a material which resists impact and abrasion.

slightly over the grooved edge to allow for any low spots in the deposited metal when finish ground. After hard-facing, the guides are allowed to cool in lime for 24 hours.

With the cast iron guides the tonnage rolled before discarding was 3000 tons; after hard-facing, this was increased to 7500 tons. The guides are hard-faced on each side and are shifted when one side becomes worn. When the overlay becomes too worn for usage, they are sent to the welding shop and resurfaced. Although this operation is being done with a torch, some mills claim

Figure 6—Welding switch points in place, against rail with which point is used, assures point having same contour as rail.



equal results with the metallic arc for applying hard-facing material; especially on roughing guides.

In another mill hard-facing materials showed no increase in wearing life over chilled iron guides. Their main difficulty was in breakage of the chilled iron guides through the bolt holes at the guide cage. The problem has been solved by using a cast steel guide, shown in Figure 3, and applying a ¼ in. layer of cast iron along the wearing face. After grinding, the cast iron is flame hardened. Flame hardening is accomplished by using a two-flame tip, with a water quench attached at the back of the tip. The cast iron surface is merely brought above the critical range and water quenched. Checking of the flame hardened surface seldom occurs, provided the operation is carried out correctly.

A number of mills using brass or bronze alloy guides reduced their scratching of steel to a minimum, but the life of the guide was very short. The usual procedure was to use one side of the guide as long as possible, and reverse the guide when the groove was worn too deep. The same procedure was then followed on the opposite side. When the guides became too worn for further usage, they were discarded. Efforts were made to reclaim them with varied results. It was impossible at first to obtain a good bond with the guide material and also to eliminate blow-holes in the added metal. The problem was finally solved by using the carbon arc process and phosphorus copper for filler material. The phosphorus copper flowed freely, bonded with the guide material very readily, and it was possible to secure a homogeneous deposit free from porosity, with wearing qualities almost equal to that of the guide.

Several mills are now repairing their alloy bronze guides in the following manner. All steel scrap in the worn grooves is first burned out with a torch. The guide is then preheated to approximately 600 degrees F., to remove all dirt or grease from the grooves. It is then thoroughly wire brushed. A ½ in. diameter carbon electrode, with welding currents from 300 to 350 amperes at 40 volts is used for melting down the worn grooves, into one large groove. Filler material, usually ¼ in. in diameter, is then added. One side of the guide is built-up to the proper height, using the carbon arc and phosphorus copper, and is then reversed. The same procedure is followed on the opposite side. After cooling, the guides are either machined or ground to a finish. As a rule, it is possible to reclaim each guide about four times before it is discarded. New guides cost in the neighborhood of $28.00 a pair. Costs for reclaiming are on an average of $8.00 a pair. Warpage can be eliminated by clamping the guides to a surface plate during the welding operation.

BUILDING-UP RAIL ENDS, FROGS AND SWITCH POINTS

One progressive transportation superintendent of a steel mill has reduced maintenance costs and the number of yard derailments per day by building up battered rail ends, switch points and open hearth frogs. A large portion of the rails are taken out of the scrap pile and placed in service in the plant yard; 80, 90 and 100 lb. rails are used for this purpose. Therefore, it is not always possible to have rails of uniform height at the joint. In such cases, the lower rail is built-up to the proper height to reduce impact and eliminate batter at the joint as illustrated in Figure 4. Rails that are of equal height, which may be battered at the joints, are also built-up as shown in Figure 5 with a material which resists impact, abrasion, and offers no problem from the spalling angle. All welding is performed with the oxy-acetylene torch, and one welder takes care of track welding for the entire plant.

The welder's equipment for this work consists of oxygen and acetylene cylinders mounted on a suitable vehicle to allow moving when required. A welding and cutting torch, with suitable tips, 2-lb. machinist hammer, flatter 2½ in. x 2 in. face, cold chisel, 2 tapered hot chisels with 2 in. face and handles, coarse rasp file (half pound) and a 6 or 8-lb. sledge are also required.

The following preparations are necessary before welding of rail ends is started. All bolts are tightened and new angle bars or angle bar shims are applied. A straight edge is then placed across the rail joints to determine the height and length of build-up on each rail. If the rails are of equal height, it is seldom necessary to weld back more than 5 in. to 7 in. on each rail. If the rails are not uniform in height, due to the above-described conditions, the length of build-up required to bring the lower rail to the height of the heavier and higher rail may be greater. A skilled operator can usually build-up the rails evenly and smoothly so that the finishing operations generally can be completed with the aid of a flatter and sledge hammer. On railroads where traffic is much faster, a grinder is generally used for this purpose. If the joints are tight together, heat is applied across the joint and the metal cut apart, squarely, with a hot cut chisel. The rail is then rounded ¼ in. along the edges and any surplus metal is removed from the side of the rail at the same time. No heat treatment is given the rail after welding. Traffic is slow in steel mills and rail end batter offers no serious problem.

Open hearth frogs can be welded in place. However, it is advisable to weld them out of service, two at a time, clamped together base to base. Warpage is then held to a minimum. The oxy-acetylene process is generally used for welding on this type of frog, also the same type of filler material, which is used for rail end welding.

Welding of manganese frogs is confined exclusively to the metallic arc process, care being taken by the operator to keep the casting as cool as possible. All checks or cracks are veed out to solid metal with a grinder before any building-up is started. The cracks are welded with 18-8 stainless steel rod. We have also found it good practice to "pad" or "tin" the surface of the frog with a thin layer of stainless steel before starting to build-up with manganese steel. We have found the stainless steel to bond well with the manganese casting and it also serves as a cushion for the added manganese. The welding is started at the greatest point of wear on the frogs. Welding beads from ¼ in. to ½ in. are deposited, using the minimum amount of current possible to get good fusion and stopping after one 5/16 in. electrode is used. The same procedure is followed with the next electrode but on another spot of the casting.

Peening follows, which tends to relieve stresses and toughen the deposited metal.

Most of the switch points welded in the steel plants are done in traffic, against the rail with which the point is used. It then has the same contour as the rail. Usually a small bead or lip is found on the stock rail after it has been in service for some time. This is heated and cut off, with a hot cut chisel. The rail is then smoothed up to allow good bearing for the point after it has been welded. Figure 6 shows a welded switch point in a steel mill track.

Generally it is not necessary to build-up over 12 in. to 18 in. of the point. Welding is started at the point and worked back towards the heel, from the bottom upwards. The point is then rounded to the proper radius and brought to a sharp edge with a grinder or rasp file.

Every welder on track work should have a helper who also acts as flagman for safe operation. Should it be necessary for an engine or cars to use the switch while it is being welded, the welding operator should first satisfy himself that the point is in such shape as to permit safe passage. Engine speeds over the unfinished point are restricted to four miles per hour and passage controlled by hand signal of the welder.

All of this track welding is being done on yard and secondary track only. For example, in one steel mill, there are over 230 switches, and 36 miles of track. Welding has been instrumental in reducing the amount of derailments from four to six per day to one to two per day, by enabling the transportation department to keep the track in repair and condition at all times.

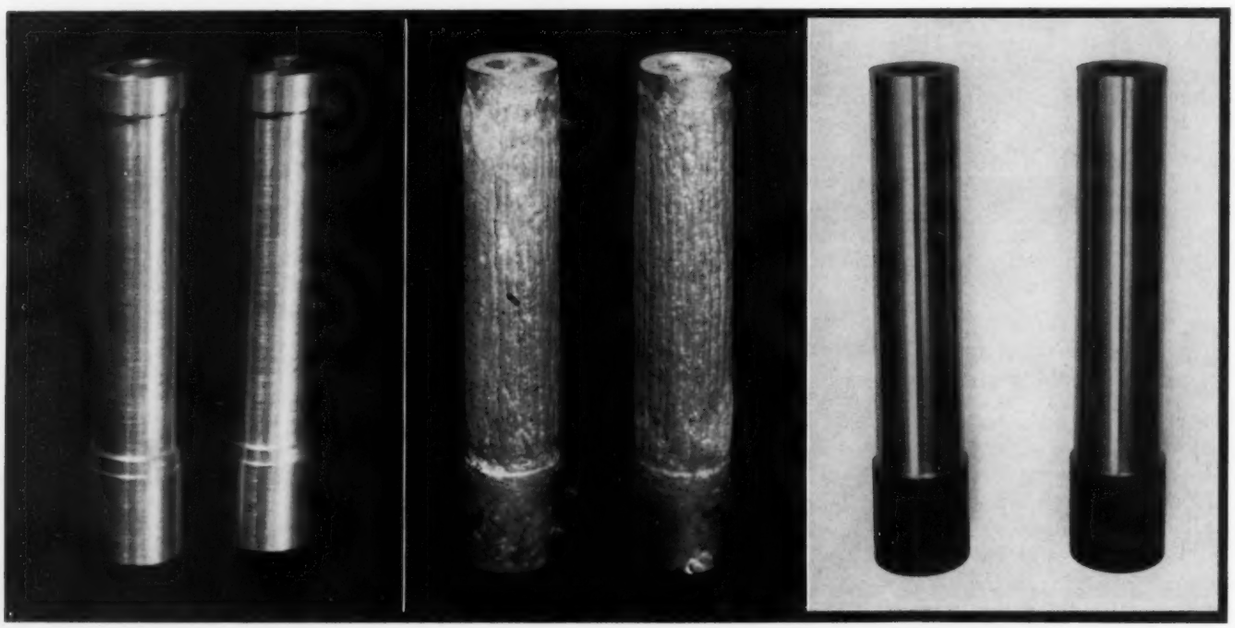
SHAFTS

There are numerous places in the steel plant where shafts are subjected to abrasion, friction, or corrosion, causing rapid wear, and making it compulsory to take them out of service at frequent intervals. In many instances their life could be increased considerably by using a material more suitable for such service or specific conditions. Parts of shafts which are merely subjected to corrosion and no abrasion, can sometimes be built-up to size, with a material such as stainless steel or nickel steel. Should both corrosion and abrasion be present, a hard-facing material with properties for withstanding both conditions should be selected. There are many good welding rods on the market today which can be used to advantage to meet these requirements.

Frequently a great deal of time and effort are spent in dismantling a complicated machine to remove a worn shaft, which is then sent to the welding shop for building-up and later is machined to size. In many instances no consideration is given to the type of material suitable for the conditions under which the shaft must operate. We have seen shafts that were subjected to the most severe abrasive conditions built-up with a low carbon steel rod that had no wear resisting qualities. This procedure is often repeated many times before some thought is given to the possibilities of using another material which might be more suitable for that particular application. The building-up phase presents no serious problems itself; however, checks do develop in the hard-facing overlays, especially on shafts of large diameters. Under proper conditions checking can be reduced to a minimum.

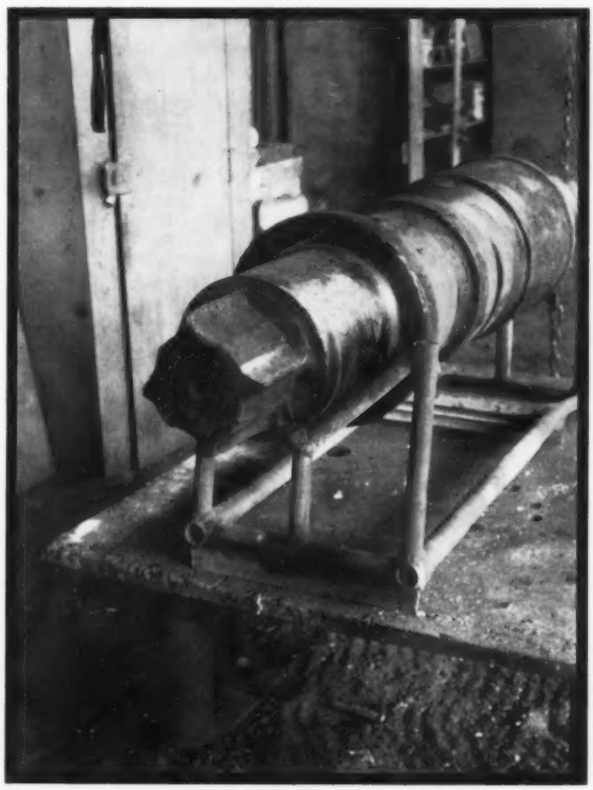
In hard-facing, the shaft is preheated to a good red heat over the entire area on which the hard-facing material is to be applied. Welding should be performed with the shaft at that temperature, and if there is any temperature drop while welding, the shaft should be reheated before any further welding is started. Either the metallic arc or the oxy-acetylene process can be used for applying the hard-facing material. The torch will help to hold the heat in the shaft while the material is being applied and is preferred. If the metallic arc is used, frequent current adjustments should be made in

Figures 7, 8, 9—Pump sleeves, hard faced by the oxy-acetylene process, are shown after machining and after finish grinding.



order to avoid excessive penetration. Welding is performed by running the welding beads lengthwise the entire length of the area to be hard-faced.

After the welding operation has been completed, the shaft should be placed in hot sand and allowed to cool slowly until the hand can be laid on it without discomfort. The length of time required for cooling depends on the size of the shaft. Hot grinding of the surplus metal is preferred, at a temperature about 500 degrees F. in the shaft. It should then be placed back in the furnace or hot sand and allowed to cool. Then, the shaft is finish ground. The finish grinding should be done with a coolant so that the shaft temperature never exceeds 150 degrees F. during the grinding operation. Some types of hard-facing materials can be rough machined with a carbide tool at reduced speeds; they are then finish ground. Figure 7 shows pump sleeves, hard-faced by oxy-acetylene process. Figure 8 shows the same part, after rough machining. Figure 9 shows these pump sleeves finish ground.



Figures 10, 11—This badly worn wabbler was built up by the carbon arc process in 6 hr., requiring 25 lb. of molybdenum-nickel cast iron rod.

WABBLER ENDS

One of the outstanding building-up and hard-facing operations, in the steel industry, is that of reclaiming worn wabblers, which has aided greatly in reducing maintenance costs. While it is an operation of long standing in most modern plants, many are still reluctant to adopt this method of welding for reclaiming their damaged or worn wabblers. Due to the substantial savings which can be affected on costly equipment, it is hard to understand why every steel plant does not take advantage of this method for reclaiming worn wabblers or alloy steel roll necks.

Reclamation of this equipment offers no serious problems, if procedures are worked out for welding rolls of the various compositions, and a suitable material is selected which is economical and retards wear. Generally, it is a simple matter to learn the composition of the roll from several sources in steel plants. The metallurgical department is usually willing to coöperate and can offer suggestions which will prove helpful. All of the standard methods of welding are being used successfully for this work with equally good results. The process selected depends largely on the roll composition and the amount of wear on the wabbler.

In most steel plants, the roll is mounted on rollers so that it can be rotated easily when positioning is required. A brick furnace is built around the neck and it is preheated to about 1000 degrees F. with a portable gas and air burner. The time required for preheating varies with the size of the roll. On small diameter rolls 3 hours is usually sufficient; on larger rolls the time should be extended. Welding is started when the roll reaches a good red temperature, using either the carbon arc or the oxy-acetylene torch for this composition of roll. The torch is preferred, unless welding machines are available which will supply current ranges from 400 to 600 amperes at 40 volts. A water cooled carbon electrode holder with 1 in. carbon electrode is used. The operator should frequently use a template or gauge to determine the amount of metal required to build up the proper dimensions of the finished wabbler. Figure

10 shows a badly worn 14 in. mill roll wabbler before building-up to size using the carbon arc process. Figure 11 shows this roll completed. The operation required 6 hours and 25 pounds of molybdenum-nickel cast iron rod were used. A cast iron blooming mill roll which was built-up by oxy-acetylene welding is illustrated in Figure 12. The roll was first preheated in a fire brick furnace to approximately 1000 degrees F. Welding time was 22 hours and 70 pounds of molybdenum-nickel cast iron rod were used. Figure 13 shows the finished roll.

Figures 12, 13—Cast iron blooming mill roll wabbler, built up by oxy-acetylene welding in 22 hr., using 70 lb. of molybdenum-nickel cast iron rod.

For welding alloy steel wabblers the procedure differs slightly. White paint or whitewash is applied to the wabbler end so it can be determined whether any checks exist at this point. When preheating is started, the oil or grease will seep out of the checks and discolor the painted area. It is then an easy matter to determine their location prior to the building-up operation. Preheating is carried out very slowly to approximately 450 degrees F. and the first bead is applied, using low carbon steel rods of small diameters. Beads are run the entire length of the worn area with each pass. The second and following passes are made with a rod of 0.40 per cent carbon steel. When the pod is nearly to size a manganese steel rod can be used for the final overlay.

When building-up roll necks the welding is generally staggered. After preheating, several beads are laid the entire length of the worn area. The roll then is turned 180 degrees and the same procedure repeated. During the winter months is usually is advisable to work alternately at four points in order to distribute the heat evenly. The beads should not be more than $\frac{3}{8}$ in. wide and should overlap each other about one-third. This is important, as only slight overlapping may cause poor fusion and dark streaks or pin holes to develop at this point.

The scope of building-up and hard-facing in the steel industry is almost unlimited. In this brief discussion it has not been possible to describe more than a few examples and methods for the reclamation of parts. Both building-up and hard-facing can be utilized profitably in every department in the steel plant on numerous other parts that perhaps now require frequent changes and replacements.

Building-up worn machinery parts usually offers no economy, unless the length of service can be extended thereby. This can only be accomplished by using a superior material for the building-up. However, this may be costly and impractical where only a small section of a large part is exposed to the abrasion or wear. In such cases a cheaper material is used for the build-up and the more expensive hard-facing material applied only to the relatively small surfaces where excessive wear occurs.

No one hard-facing material is suitable for all applications, or conditions and many of the failures which have come to our attention can be attributed to the use of the wrong material or the wrong process for the job. For example, we know of a case where a hard-facing material was applied with the electric arc to a worn area on a die. Upon cooling checks developed in the overlay which spalled in service. In welding, the hard-facing material had intermixed with the base metal, thus increasing the carbon content of the overlay and causing checking and spalling. The same die was preheated and the same material was applied with an oxy-acetylene torch with no subsequent checking or spalling.

While most of the literature stresses the importance of proper techniques, for application of hard-facing materials, comparatively little information has been given regarding precautions necessary after deposition. This also plays an important part in preventing cracking of the deposit. Cracking generally can be attributed to the differences in coefficients in expansion and contraction between the overlay and the base metal. More research and study on this problem should prove valuable and interesting.

Both building-up and hard-facing are playing an important part in reducing costs in the steel industry. But to secure maximum benefits, they must be used in the right place and at the right time. In the face of the present emergency, with the attendant difficulty of procuring new replacement material, the value of reclaiming and prolonging the life of worn equipment cannot be over emphasized.

DISCUSSION

PRESENTED BY

W. S. WALKER, *Manager*, Process Service, Eastern Division, Linde Air Products Company, New York, New York

C. C. KEYSER, *Welding Supervisor*, Bethlehem Steel Company, Steelton, Pennsylvania

L. AMES, *Supervisor*, Applied Engineering Department, Air Reduction Sales Company, Pittsburgh, Pennsylvania

L. J. GOULD, *Assistant Chief Engineer of Construction*, Bethlehem Steel Company, Bethlehem, Pennsylvania

J. B. WHITLOCK, *General Maintenance Engineer*, American Rolling Mill Company, Middletown, Ohio

LOUIS MOSES, *Superintendent*, Rail Mill and Roll Department, Maryland Plant, Bethlehem Steel Company, Sparrows Point, Maryland

W. S. WALKER: Mr. Ames has very adequately covered the subject and his description of specific jobs should suggest a great many other possibilities. He mentioned that there were many additional applications. I am sure we all agree with him in this statement. In fact, the list is almost endless for it might be said without much exaggeration that everything subjected to wear can be built up or hard-faced. Such a statement, of course, must be tempered by good judgment. Parts subjected to severe abrasion, corrosion, high temperature or lack of lubrication can be made to give better performance, more continuous operation or a better product. On such items the saving is not always in the direct maintenance cost, although it frequently is. Larger savings are often reflected in more economical operation of the mill and improvement of product.

Mr. Ames has described some of the precautions necessary when welding hard alloys to ferrous surfaces to resist wear. There are many of these alloys on the market and they usually have a different coefficient of expansion than the base metal being repaired. Correct preparation and technique will pay didivends in this kind of work to avoid later spalling and checking of the hard surface or base metal. As a rule no trouble will be experienced in case the part is properly preheated during welding and then allowed to cool at a slow enough rate. Since the base metal is almost always heavier and stronger than the relatively thin and less ductile surface coating, it is necessary to give the base metal time to creep or upset at an elevated temperature so as to partially conform to the stresses in the hard coating. The mass and composition of the piece being hard surfaced plays a great part in determining the proper type of welding rod to use, particularly since the shape of the piece will determine the ease with which it may upset. When this act is once accomplished and the piece is properly cooled to room temperature without checking, you can know that the alloying material has a good bond with the base metal and should give no further trouble on this score.

I was particularly interested in those parts of the paper concerning the use of bronze for building up operations on cast iron. Again Mr. Ames has stressed the importance of proper preparation before applying bronze. It has been my experience that machining tends to "smear" the graphite flakes over the surface of the cast iron which prevents proper tinning action. Grinding can have a similar tendency. Chipping by hand or with an air hammer does not give this trouble. Sand blasting or "searing" with the blowpipe flame can be used to correct this condition and present a surface suitable for the application of bronze. There is now on the market a bronze containing iron and tin which has greater wearing properties at elevated temperatures, such as occur in ordinary steam engine cylinders, than the formerly used manganese bronze.

The paper also mentioned the flame hardening of built-up surfaces to increase their resistance to wear. Steel and cast iron welding rods now on the market are applicable to this use for a wide variety of objects for a moderate hardness alone or where hardness with toughness is required. Where desired, the hardness of the deposit can be kept within machineable limits thus allowing a greater hardness to be obtained by flame hardening after machining. Where long life and maximum production are demanded, and where unusual conditions of abrasion and wear prevail, the standard hard facing alloys have a longer record behind them than the flame hardening of deposited steel and cast irons. However, these deposits cannot be machined but must be ground to final dimensions where this is required.

C. C. KEYSER: In describing the building-up of worn cast iron pistons Mr. Ames states, "It is sometimes advisable to either grind or sandblast the surface before any bronze is applied." I do not think much of grinding but I certainly feel that the use of sand blasting is very worthwhile and should be almost standard practice. A year or so ago our shop purchased a portable sand blast outfit and it has been most useful. The sandblast is easy to handle and removes all scale, rust, graphite or dirt from the piece to be welded or brazed more effectively than any other method I know of.

The different methods used for surfacing mill guides are very interesting. In our plant we hard surface the

guides in the finishing pass of the rail mill. We hard face them at about 1100 or 1200 degrees F., but instead of a gas fired furnace use charcoal. We started out using a gas furnace but later changed to charcoal. While charcoal may cost a little more than gas it has a number of advantages that we believe make it worth using. Probably the most important difference between gas and charcoal is the comfort of the operator. Charcoal will maintain a better heat in the piece being surfaced without nearly as much heat reaching the operator.

Another very important difference is that the atmosphere in a charcoal furnace is decidedly reducing and the surface being faced remains clean and free of scale much better than when gas is used in the furnace. In all respects we have found charcoal much more satisfactory than gas for preheating.

The description of hard surfacing shafts is very interesting. Grinding of the surplus hard metal at a temperature of 500 degrees F. is recommended. It would be interesting to have a further explanation of this procedure and the reasons for grinding at this temperature. Is this temperature used to make the grinding easier or to produce a better job, that is, fewer checks?

L. AMES: In the case of hot grinding they are generally able to hog the hard-faced material off the shaft. For instance, when they have the temperature from 500 to 700 degrees F., they generally are able to hog it off much more rapidly than they can when the material is cold, which is one of the advantages. Then, too, we find that when they use a coolant, they hold it about 150 degrees and never let it build up over that.

C. C. KEYSER: Some time ago we had occasion to hard surface a shaft about 4 in. in diameter. The work was done in a charcoal furnace with the job at a good red heat. After welding was completed the furnace was filled with charcoal and closed and the fire left to burn out. The job was perfect when the welding was completed however, during cooling a single crack developed the full length of the deposit. Would cooling in hot sand and hot grinding have prevented the formation of this single crack?

L. AMES: How hot was the shaft preheated prior to hard-facing?

C. C. KEYSER: Approximately 1100 or 1200 degrees F.—and the shaft was a solid shaft—just one crack developed.

L. AMES: We have had some difficulty in the checking of hard-faced materials, especially on the larger diameter shafts. Did you do it with acetylene or with an electric arc?

C. C. KEYSER: With acetylene.

L. AMES: Most of the trouble, we found, was due to the fact that the operator was using a tip too small for the application. What probably happened in your case was that your surface may have cooled off slightly during the application, and of course when you tried to cool it off slowly or stress relieve it, it started to check. In other words, the coefficient of the expansion and contraction wasn't exactly right.

Another thing that may have caused it to check would have been the wrong type of material on the shaft. On large diameter shafts, I believe that one of the softer grades of materials on the market would have been more suitable.

C. C. KEYSER: Would letting the hot sand cool be better than letting your fire go out? Do you have your sand hot before you put the piece in?

L. AMES: No, I would say that a furnace would be the ideal place in which to cool off a hard-faced shaft. We generally cool them by dropping the temperature 100 degrees per hour, until the shaft reaches 600 to 700 degrees and then turn off the gas in the furnace, allowing both the shaft and the furnace to cool down slowly.

Generally, the ordinary furnace built for this purpose is not very tight, and if the shop doors are left open the cooling is too rapid, which causes checking of the hard-faced overlay. We, therefore, usually like to place them in hot sand or hot lime for this reason.

L. J. GOULD: I would like to say something here with regard to the metallurgical damage that you do to the metal that you weld on. I ran a little experiment at one time just to see what would happen with one of the hardest of the hard-faced materials. We welded on a .35 carbon rectangular block about 8 or 9 in. long—which was pretty close to the checking limits almost on that grade of steel, that is, checking the hard-facing—and after we welded it under various conditions, we put it under a drop hammer and just hammered on it until something happened.

We put a layer a little greater than one-eighth of an inch thick, possibly three-sixteenths of an inch in thickness, and we had first an annealed .35 carbon steel block and then we had a quenched and drawn .35 carbon steel block, and we welded on both of those preheated and not preheated, and then we took the welded blocks and heat-treated those with the welded metal overlay on them, after which we subjected them to this drop hammer test. It was amazing to find that we got very good results by the quenching and drawing of the welded block, and there was a vast difference between the block that was heat-treated before the welding and the one that was heat-treated afterwards.

The chances are largely that when you build these hard-faced surfaces, even on a material which you say is strong, .50 or .60 carbon steel as is often recommended, by the time you get it on there some thin layer of that metal—not always but sometimes, based on the mash you have—is weakened at least so that it is no better than if it were in an annealed condition.

As for this business of putting hard-faced material on shear blades, which I don't believe was mentioned to any extent, and then expecting that edge to support something on an ordinary carbon steel that is annealed, I think that is the cause of many failures of hard-facing. And it is quite difficult to get away from that because on these shear blades of any length the chances are about 99 out of 100 that you are going to crack the hard-facing material in several places when you quench it; but on short-flying shear blades 12 or 14 in. long that has been done quite successfully. The material built up on it, I believe, was .60 or .65 carbon steel, and it was quenched and drawn and used in the regular operation of shearing hot steel.

There is one other thing about the use of the stainless steel—this wasn't covered exactly although it may have been implied—built up under the hard-facing. Not all

stainless steels but the 18-8 and the 25-12 have a coefficient of expansion fairly close to that of Stellite and Stoodite, I believe. Both are somewhere near the same. Besides that, this particular grade of stainless steel has a fair elongation without its failure being any greater than your overlay casting, so that when your material starts to shrink, the bond between the stainless steel and the hard-facing is maintained because they are shrinking at the same rate and through the stainless steel are developing stresses which do not cause it to fail because of its ability to take considerable elongation.

L. AMES: Most of the stainless steel rods which we have used to resist corrosion have been applied by the electric arc, and in most cases we have had very successful applications; we also have had successful applications using stainless steel to resist heat and also a certain amount of abrasion. Where there is impact, the stainless work hardens and gives very good results; it is inexpensive to apply, especially in steel plants that make stainless steel.

J. B. WHITLOCK: There is one question I would like to ask. I am wondering if you have had any experience with coke pusher shoes. Down at Hamilton we find that we get about three months' life out of the original casting. I think we have tried just about everything on the face of the earth and so far we haven't been very successful.

L. AMES: We have had some very good results with coke pusher shoes when they are made of cast steel and we hard-face them by the acetylene process. By doing this we have found that we have had an increase in wear; that is, the life of a hard-faced coke pusher shoe then had a ratio of about five to one—in some mills. In other mills they will run a test and invariably a superintendent of the coke plant or master mechanic will tell us that they have had no increase in life, so I suppose it all depends on the plant and the type of work they do. Those who are using hard-faced materials on coke pusher shoes claim a ratio anywhere from five to ten times as much life as that gotten from chilled cast iron or steel shoes.

LOUIS MOSES: The illustrations which Mr. Ames has chosen contain a number of worn parts of a rolling mill. I wonder how the edges of the product must have appeared after going through such badly worn guides, and how much difficulty the mill had in controlling the bar's travel by such means. I could not say that similar examples are not present in our own mills, and are not just as fully subject to criticism. But I do know that these are far and few between and when they would occur the fault lies with the mill settings.

Without going into a long discussion of the reasons why a bar will hook or pull it is easily understood that roll openings must be maintained relatively parallel to one another at every pass. Otherwise a very slightly tapered bar, even only of a few thousandths of an inch, entering a subsequent parallel roll setting will cause a very considerable camber and, in the effort to control this, the guides could be worn in the manner shown.

We also use hard surfacing on rail mill guides as Mr. Keyser stated is the case at his plant. I have remedied guide troubles on rails, and on other sections as well, by analysis of relative amounts of drafting imposed on the component parts of the section. This accomplished a better straight-away delivery, lessened tendency to twist and a considerable lessening of pressures on guide faces. Frequently the relative diameters of upper and lower rolls have a lot to do with this.

Perhaps mill pinions would have been a better choice in illustrating wabbler wear as pinions are expected to last for years. But a well designed roll wabbler, if decently treated, water run on the boxes for even such slight lubrication and the coupling boxes held to the full lengths of wabblers, should more than outlast the body life of any roll, so far as flute wear is concerned. The amount of pod wear is shown as being very considerable and I wonder why this was allowed to happen to a roll. It may be that the spindle approaches the roll at an angle in which case a ball shaped wabbler, on the roll or spindle, or on both, would eliminate such wear.

I would say that a great difference exists between hardness as such and the ability to resist abrasion and indentations. Sometimes the two go together but not always. A case in point is the hard surfacing of rollers used in a roller twist guide. Exclusive of the cost of the roller $40 to $50 was being spent to hard surface these and the rollers would not last one week or at most two weeks. Out of dozens of these only one pair gave anything near a satisfactory life. Rollers made of an alloy iron at a cost of about $35 were found to outwear the hard surface rollers many times over and in terms of reduced bar marking and avoidance of mill delay the improvement was very great.

The term hardness does not convey the desired meaning. A cupola melted sulphur chilled roll can be scleroscoped up to 80 hard but will not run in the mill without tail marking and within an hour be badly worn out of shape. An air furnace normally made chilled-iron of 65 hardness will run for many hours and even days. Here again we find a distinction between hardness and abrasion resisting qualities.

I certainly would not even hint at discounting the value of hard surfacing. In itself it has solved many a troublesome condition. Therefore we can all hope to see greater advancement in the technique and extension to the field of usefulness. But allow me to stress the fact that our mill operators and personnel can become too greatly dependent upon it to the exclusion of proper attention being paid to the underlying causes of undue wear on ordinarily graded metals.

L. AMES: That is true. There is a great deal of difference between hardness and the ability of a material to resist abrasion. In some cases hard-facing materials of medium hardness will outlast more expensive and harder materials on certain types of work. I tried to point out where this was the case in some instances on mill guides. The problem is to find the right type of material for the job. In other instances a material such as rubber will outwear the hardest type of hard-facing material. On a certain type of pump liner it was found that a rubber liner would outwear the hardest and most expensive hard-facing material it was possible to obtain; however, these are isolated cases. On most parts subjected to wear in and around a steel plant the length of life of these parts can be increased considerably if each problem is approached and worked out individually and the material is used for the overlay which has been found to be most economical and will prove most satisfactory for the application.

APPLICATION BEARINGS

By F. L. Gray, Lubrication Engineer

CARNEGIE-ILLINOIS STEEL CORP.

GARY, INDIANA

▲ THE application and care of bearings in steel plant auxiliaries is a topic that has received much attention from the lubrication view point in the past decade. On recent equipment the design engineer has indicated a thorough grasp of lubricating requirements and has simplified the operator's problems by the application of improved bearings and provisions for proper care and maintenance.

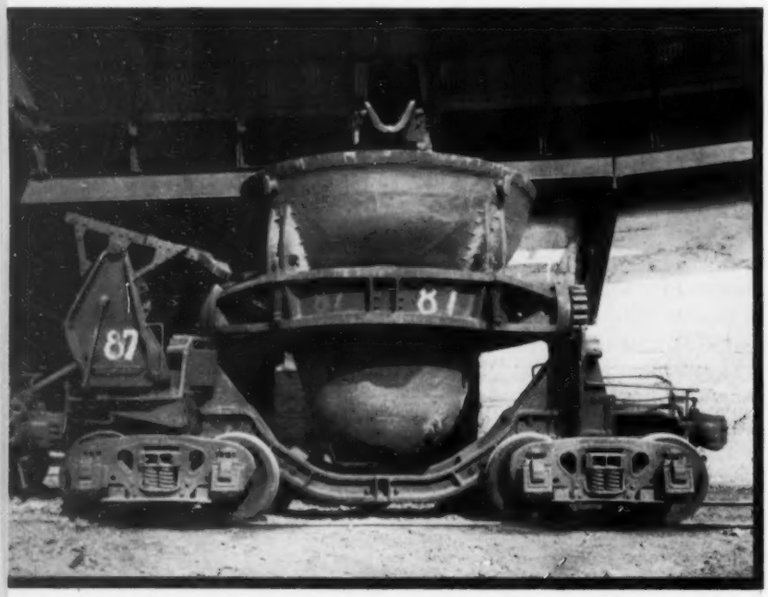
The improved design has shown by contrast with older type of equipment, what is possible in the way of reduced maintenance and cleaner, safer, and more economical operation. It is a challenge to improve lubrication of the older auxiliary bearing design. This paper deals with this class of equipment.

PRESSURE SYSTEMS

In the lubrication of older steel mill equipment, black oil, the cheapest and least refined of the lubricants, attained universal use. As a lubricant it did its job remarkably well. Pinion, line and drive shaft, and table roll bearings were supplied by gravity flow from a container or through an oil soaked mass of cotton waste. Excess oil found its way to the floor, sewer, or into the concrete foundations. It has been our opportunity to clean up, and in most cases, to materially improve lubrication by the installation of pressure grease systems.

Usually some change in the design of the bearing was necessary. On a three high pinion housing, the black oil dropped by gravity into the top bearing and from there to the middle and bottom bearings from whence it traveled to the inside of the gear case, diluting the gear lubricant, while the excess flowed to the outside of the housing. In remodeling equipment of this nature, the oil holes, which had been in the top and bottom of the bearings, were plugged and grease holes drilled into the bearings at points where the pressure during operation is at a minimum. A change of bearing metal with proper anchorage and grooving was made. A grease pump driven from the line shaft will supply a constant flow of grease during the operation of the mill. On this type of application, however, it was found feasible to place the grease pump in a protected location and change the method of driving the unit by using a fractional horsepower motor for the power supply, with the starting and stopping switch on the control panel of the pinion drive motor. Service life of the pinion bearings has been increased two to three times by this change in lubrication practice.

Felt pad lubricators with a good grade of oil are used on the journal bearings of this cinder ladle.



One of these units eliminated a constant stream of black oil on the brass bearings of two vertical rolls used for hot rolling the flange of a car wheel. Bearing wear and distortion of the brass formerly required daily changes. Four pounds of grease replaced 30 gal. of black oil per day and the first bearing change was made after 21 turns of operation.

Improvement has been made by the application of pressure grease systems on table roll bearings with a well in the top bearing cup for saturated waste, using black oil as the lubricant. A solid cap was designed to replace the old one and the grease connection made in the customary way.

To eliminate the hazard of workmen climbing about an overhead crane to lubricate by hand the many bearings of both the bridge and trolley, a pressure grease system operated from an accessible location is not only a safety measure but also is good housekeeping. Journal bearings on coal bridge trolleys connected to the pressure systems are giving satisfactory results. Further study will be made of this method of application on other type cranes.

and CARE of in Steel Plant Auxiliaries

Presented before A. I. S. E. ANNUAL CONVENTION, CHICAGO, ILLINOIS, SEPTEMBER 24-27, 1940

Bearings of process machinery are more efficiently maintained by the application of pressure grease systems. In hand oiling or greasing it is an easy matter to neglect certain bearings through no intent of the individual, but rather through fault of the system.

The top bearings of blast furnaces are customarily lubricated by two men working together, equipped with self contained respirators to guard them against the gas hazard. Positive lubrication of these bearings is now assured by the installation of a small hand compressor located in a steam heated brick building on the ground level. The feeder lines follow the inclined skip hoist bridge to the furnace top. To facilitate operation in cold weather, a steam line is run adjacent to the feeder line and both lines covered with proper pipe insulation. Fifty-seven bearings on one of our furnaces are serviced by one system. This includes the bearings of the skip hoist sheaves, the mechanisms of the large and small bells, and the revolving distributors.

There are about 364 line shaft bearings in a blast furnace stock house. This includes eccentrics, friction pulleys, main drive, intermediate and drive shafts. Positive lubrication for such a number of bearings is impractical by the hand method of oiling each bearing individually. A hand operated compressor for each one hundred bearings has given us satisfactory results.

Manufacturers of lubrication devices have improved and perfected the centralized control system for strained greases. Periodic inspection and maintenance of these systems will assure the efficiency expected from this type of equipment.

HIGH TEMPERATURES

Roller bearing temperatures of 450 degrees F. on runout and transfer tables are no longer a maintenance problem. Grease manufacturers have successfully designed a product to meet these temperatures without wastage or excessive usage. The grease recommended for high temperature applications is usually a high percentage soda soap base and a straight mineral oil with a viscosity above 2000 SSU. at 100 degrees F. At temperatures ranging between 450 and 900 degrees F. satisfactory results have been attained by using brass

The bearings of these horizontal twin tandem gas engines are lubricated from a central oil circulating system.

bearings with compounded graphite inserts. The graphite reduces friction, prevents metal to metal contact and seizure, and protects the brass from wear. No oil or grease is used and surroundings are much cleaner.

On the bearings of the reversing and slow moving rollers of a normalizing furnace, oil carried up by the ring to the shaft created an unsightly appearance as it worked its way out at the bearing end. The rolls were in the furnace atmosphere, but the bearings were outside of the heating zone and not subject to excessive temperatures. A full carbon shell ¼ in. in thickness, with no oil or grease lubrication was tried as a bearing in this location and showed good results for 90 days with no apparent wear. At the end of this period, however, the shell broke into several pieces. Failure could not be attributed to shock during the roll operation. A set of brass bearings with compounded graphite inserts is now being tried and friction losses with this type of bearing will be studied.

JOURNAL LUBRICATORS

More attention is now being given to the prevention of oil drippage from crane journal bearings of the oil cellar type. The presence of oil under crane runways is not only unsightly and hazardous but also causes damage to products temporarily placed underneath. The extended use of oxygen piping systems has required the elimination of the oil drippage nuisance. These stations, of necessity, must be placed along crane travel ways. The rapid oxidation of oils or greases in the presence of oxygen under pressure is well known and safety measures must be taken to prevent this condition.

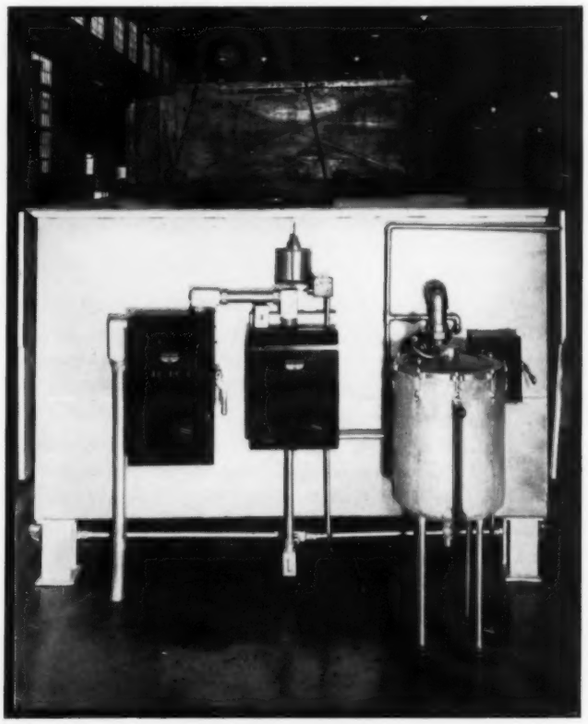
The common method of using wool waste with black oil for lubricating crane journal bearings required daily additions of oil to replace drippage and losses from the waste cellar caused by sudden stops of the crane. Impurities in the black oil caused glazing of the wool waste, necessitating frequent attention. A better grade of oil required less attention and provided better lubrication, but oil drippage was still evident and consumption excessive. A light lime base grease impregnated with long horse hair as a substitute for wool waste did not prove practical under continuous, hot, or heavy operating conditions. The horse hair wound around the shaft, did not supply sufficient lubricant to the bearing surface, and required too much attention.

A felt pad held in cylindrical form by flat steel springs, with light chains to prevent undue expansion or unnecessary pressure against the journal, has given excellent results. Each pad must be designed for a particular bearing and oil cellar. Prior to use the pad is soaked in oil for at least four hours and drained. The oil which has given the best results is a straight mineral oil compounded with 3 per cent of latex. Oil at 900 SSU. at 100 degrees F. with a low pour test is used for atmospheric temperatures below 40 degrees F. and 2200 SSU. for atmospheric and mill temperatures above that point.

Felt lubricators installed as of July 1, 1940, total 2148, applied as follows: 1886 on overhead cranes, 32 on open hearth charging cars, 96 on coke plant and blast furnace transfer cars, 12 on blast furnace cinder ladles, and 122 on ore bridge trolleys.

On the journal bearings of a blast furnace cinder ladle truck, black oil had been used, with daily additions. The wool waste was replaced by pad lubricators, and daily inspections were made. No oil was added for 40 days on the first test and 56 days on the second test. An ore bridge trolley installation had a sufficient amount of oil retained in the felt pad after 60 days of service for further operation.

In general, these pad lubricators have provided more positive lubrication, required less maintenance, and have reduced oil drippage, but their application is limited. Where the oil cellar is too small to permit the use of a lubricator large enough to provide for sufficient area of contact and an oil reserve, or where the design does not facilitate inspection, or where the lubricator cannot be inspected without dismantling the bearing assembly, this type of lubricator should not be used.



View showing degreasing equipment for cleaning roll neck roller bearings with housing.

Furthermore, abnormal heat, weather, and unclean atmospheric conditions are unfavorable to this type of lubricating equipment.

NON-METALLIC BEARINGS

Although non-metallic bearings were designed primarily for use on roll necks, applications in other locations have proven satisfactory in the solution of lubricating problems. An example is the installation on a furnace table of a bar mill. The table is directly in front of the reheating furnace and receives billets from

4 in. x 4 in. x 15 ft. up to 9 in. x 12 in. x 15 ft. from a 45 degree skid. Temperatures are high, shock loads severe, and lubrication was inadequate. Brass bearings lasted about two weeks and rolls a year. On September 24, 1937, new rolls were installed throughout, equipped with non-metallic bearings of fabric composition type. Split grooved bearings 3 in. diameter were installed on the gear end and full grooved bearings on the opposite end. Water was piped to the oil hole in the cap and wasted to a sewer. Roll necks were file finished. To date no rolls have been changed and only four bearings were replaced because of damage caused by stoppage of the water supply. The use of non-metallic bearings in front of reheating furnaces is being extended as roll replacement becomes necessary.

Excellent results are being obtained from composition type bearings on spray tables, where the high pressure water and scale makes grease lubrication difficult. One installation has given sixteen months' service to date without bearing replacement.

In strip coilers where speeds are high, non-metallic bearings were installed by the machine builder, and are giving good service with yearly replacement. Where salt is used as a scalebreaker on plate mills, the phenolic composition material of the bearings reacted with the salt to cause failure. Moulded bearings which have been treated to withstand this condition are now being offered by the manufacturers.

Grease lubricated non-metallic moulded type bearings have given good service in heavy duty applications where speeds are low and water cannot be used. Bridge bearings of a hot metal crane were equipped with this type of bearing on September 1, 1939. After eight months of operation, in an atmosphere of graphitic carbon from the pouring of hot iron, not more than 35 per cent wear was shown. Graphitic carbon acts as an abrasive where metallic bearings are used and causes excessive wear. In the non-metallic bearings it works into the fabric and forms a glazed surface which reduces wear and prolongs bearing life. Under cleaner atmospheric conditions results did not warrant the installation of non-metallic bearings.

HARDENED STEEL APPLICATIONS

There are some problems that involve bearing design where frictional wear of metal-to-metal surfaces is difficult if not impossible of correction by lubrication.

For several months a study was made of the operation of the chilled cast iron wheels and heat treated 40/50 carbon pins of pig machine mould and chain conveyors. Attempts were made to develop a practical recommendation for positive lubrication of this equipment and elimination of the hand oiling method whereby oil was poured on the exposed portion of the pin, depending upon capillary action to wet the bearing surface. No feasible means of improving the lubrication was apparent whereby the approximate service life of five weeks could be bettered. Upon the recommendation of a manufacturer of hardened gears, 500 forged steel wheels hardened in bore and tread to 85/95 scleroscope, and hardened pins were installed. Without lubrication, after ten months' service, no visible wear is apparent.

Many cases will be found where an improvement in lubrication is impractical. In these instances, hardened steel applications or hard facing of the wearing part will materially aid in reducing maintenance.

THE INTERNAL COMBUSTION ENGINE

An auxiliary within the steel plant, the internal combustion engine using blast furnace gas as a fuel, offers the lubrication engineer a challenge in the maintenance of the circulating oil supplied to the bearings and bearing surfaces. In gas engine operation, the large amount of make-up oil and the large amount of labor and material necessary to keep the oil and the system in an operating condition are factors that increase operating costs. The present methods of treating the oil in service or replacing it with the new oil after the danger point has been reached, are not conducive to economical results. The cause and not the effect must be treated to modernize this condition.

In circulating systems on this type of equipment a straight mineral oil with a viscosity of 130 SSU. at 100 degrees F. is used as make-up. It is necessary to use this low viscosity oil to maintain the viscosity of the batch at the required point. Heating, washing, and cloth bag filtration are used to maintain the oil in service. Acidity and viscosity of the oil rapidly increase with resultant sludge or oxidized deposits.

An analysis of the oil being used disclosed a neutralization number as high as 9.7, a viscosity of 306 SSU. at 100 degrees F., and a chloroform soluble of 0.19 per cent. The steel points of the needle valves were badly corroded and galvanized baffle plates in the filter were reduced to one-third their original length. Bearing surfaces lacked that oily appearance so necessary to good lubrication.

Temperatures were maintained at a maximum of 155 degrees F. in the heating tank of the return system. The steam coils were below the water level and free of the oil area. Experience as to the proper temperature and location of the coils had been gained through the unintentional use of superheated steam when the coils were in direct contact with the oil. A solid deposit in the heating tank resulted, such as might be expected from chemical reaction and physical separation of the various hydrocarbons.

Caustic soda (NaOH) was used as a neutralizing agent. A solution of 1000 gallons of 1 per cent caustic solution for 1000 gallons of oil was calculated for the condition existing, and the solution was slowly added during the agitation of the oil by air jets located in the bottom of the tank. The oil was then washed by bubbling through water, centrifuged, and returned to the system with a neutralization number of approximately 0.4. To keep the acidity within a workable range, it was found necessary to treat the oil at least bi-monthly, or better still, with a continuous by-pass arrangement.

Feeling that possibly the continued rise in acidity might be aggravated by deposits in the piping system, the entire system was shut down, cleaned, and a new oil of proper viscosity and good oxidation resisting qualities installed. After 30 days of operation the neutralization number was 2.98. The oil was sweetened by the addition of 20 per cent make-up, but after another

30 days the acidity had risen to a neutralization of 4.05.

A single unit with an individual circulating system and new oil was then placed in operation. After 154 hours of operation and the acidity at 0.38 neutralization number, a "BAP" inhibitor was added. After 317 operating hours the acidity had risen to 0.59. In a similar unit under like conditions except that no inhibitor was added the acidity reached 1.43 after 317 hours of operation. The "BAP" inhibitor under the conditions described is effective for 300 hours or less. It was also noted that the rate of oxidation was slow with new oil and increased more rapidly as the acidity became higher.

A filter of absorbent minerals such as bauxite, fuller's earth, and wood fiber cellulose to remove the carbonaceous materials, asphaltenes, and other constituents having acid and sludge forming properties, is now being considered.

These are all expedients for the treatment of the effect. The cause lies in the severe service to which the oil is subjected. Excessive heat from too close contact with the exhaust gas areas will cause cracking or thermal decomposition of the oil. Improper oil grooves in the main bearings, or the action of the crosshead at the end of a stroke, are contributing factors to abnormal oil film pressures.

Iron dust settling on the slides, lead, tin, or antimony particles from the bearing metal, or blow-by gases from the cylinders, may be the catalyst that acts upon the oil in the presence of heat and pressure extremes to form the acid radical with the resulting sludge deposits. An examination of these possibilities did not support the assumption. Oil travels were checked and found to be free of conditions of high or low pressures in the presence of temperatures above the boiling point of the oil. Where this condition exists the oil would not be given time to distill in the ordinary manner but would crack or decompose into simpler hydrocarbons having lower boiling points.

Oil grooves were checked and no evidence of hot or even warm bearings or noticeable bearing wear that would surely result from abnormal oil film pressures, was discovered. Blow-by gases or cylinder oil carried out with the rod which might contaminate the circulating oil was found to be nil. The amount of wear from the bearings containing lead, tin, or antimony was too small for measurement. The use of the oxides of iron as an oxidizing catalyst to derive a partial oxidation of the oil molecule without complete oxidation to CO_2 and H_2O would require temperatures of possibly 400 degrees F. or above. Although the action was that of free fatty acid, no fixed oil was found in the analysis of the new sample. Free mineral or resin acid as the result of processes of refinement was not indicated.

The studies and observations, which have been made by the operating personnel within the Gary Works, of the blast furnace gas engine circulating oil in its several stages of physical and chemical change have been the source of definite opinions and conclusions.

By the process of elimination it is concluded that modern methods of refining crude petroleum have not resulted in a procedure for the elimination of the olefines or unsaturated molecule. This unsaturated molecule, possibly of the chain type, olefine series (C_nH_{2n}), under ordinary operating conditions becomes a carrier of oxygen and develops fatty acid characteristics. Although petroleum acids, developed in circulating oils, through oxidation during continuous use, are very weak and affect no metals except lead and zinc, they produced metallic soap which settled in pipe lines and storage tanks, attacked needle valve metals, and exhibited definite qualities that could place them in the fatty acid classification.

Polymerization, or the forming of larger molecules from two or more molecules of olefine gas, is possible in the presence of heat, with or without a catalytic agent. As far back as 1910, C. E. Waters of the Bureau of Standards, reported from a German publication of 1891 that air passed through heated mineral oils produced acetic acid (CH_3COOH) in the water formed by oxidation, and that the distillate had the odor of other members of the series of fatty acids. From a publication of 1892, Waters also reported the formation of butyric (C_3H_7COOH) and other fatty acids by blowing air through hot, neutral petroleum.

In an attempt to learn something of the unsaturated qualities of the oil, three new oils with neutralization number of .03/.04 showed iodine values, or the number of grams of I_2 absorbed by 100 grams of oil, of 0.52, 2.13 and 2.74. The first oil contained an inhibiter and had proven its ability to withstand the effects of oxidation in turbine service. The second oil was used in gas engines as make-up and showed an iodine value after use of 3.35 with a neutralization number of 3.20. The third oil was a sample of oil that had given acceptable service in another plant.

Whether the iodine values given are by substitution or by addition is problematical. In the case of the new oils, the indication is that the unsaturated molecule absorbs the iodine by substitution, while the acid radical of the used oil may cause other effects.

This being the case, the acid forming properties of a circulating oil can be greatly retarded by the effective use of an inhibitor. Where dirt, water or other conditions require frequent replacement or excessive make-up, acidity will be of no concern. With proper care, however, we would like to assume that oil does not wear out, but experience has shown that the maze of formations of the hydrocarbon molecules which make up our lubricating oils cannot withstand the influences of oxidation to which all substances must eventually yield.

The oil refiner through his research may develop an inhibitor to meet the conditions of the gas engine. Excessive temperatures, rapid circulation and cleaning methods are problems of the operator. Together, a solution will be worked out whereby the bearings of this class of equipment will receive a lubricant capable of performing continuous and economical service.

CONCLUSION

In summarizing, it may be pointed out that no attempt has been made to go into the theory of solid or fluid friction and qualify the type of lubricant used.

For too long a period, the cost of lubrication per ton of steel has included the total cost of the oils and greases consumed. A change to a better quality oil was represented by an increase in the cost per ton of the

product for lubricating purposes. Mill delays and repairs as the result of the failure of lubricated parts are now corrected by improved lubrication methods, with the increased cost balanced against the saving in maintenance. No matter how ancient the practice or obsolete the equipment, it is the responsibility of the lubrication engineer to recommend the lubrication that will best reduce the cost of maintenance and provide a safer and cleaner place in which to work.

To this end it has been our aim to displace the use of inferior lubricants and at the same time reduce the need for the oil can or grease bucket, thereby eliminating waste, reducing maintenance, building up efficiency, and contributing to reduction of the working hazards of the individual.

DISCUSSION

PRESENTED BY

S. M. WECKSTEIN, *Chief Engineer*, Industrial Division, Timken Roller Bearing Company, Canton, Ohio

W. C. BAUER, *Chief Engineer*, Briggs Clarifier Company, Washington, D. C.

G. F. BOWERS, Technical Division, Standard Oil Company of Indiana, Chicago, Illinois

F. J. THOMAS, *Lubrication Engineer*, Republic Steel Corporation, Cleveland, Ohio

F. L. GRAY, *Lubrication Engineer*, Carnegie-Illinois Steel Corporation, Gary, Indiana

W. H. MANDY, *Lubrication Engineer*, Texas Company, Birmingham, Alabama

J. L. HAYNES, Hyatt Bearings Division, General Motors Sales Corporation, Chicago, Illinois

E. S. GLAUCH, *Special Representative*, Lubricants Sales Department, Joseph Dixon Crucible Company, Jersey City, New Jersey

S. M. WECKSTEIN: Mr. Gray's paper is extremely interesting since it brings out the necessity of proper study of the bearing and housing design from the lubrication standpoint. In preparing designs for bearing applications, we recommend that the cycle of operation, loading, speed and operating conditions be thoroughly studied. With this information it is possible to provide in the design for proper lubrication, inspection and ease of assembly and disassembly.

It is pointed out in Mr. Gray's paper that he is dealing primarily with the design of the older auxiliary equipment to which he has applied improved lubrication methods. From the standpoint of anti-friction bearings, it has been very difficult to change over many of the older auxiliary units from friction to anti-friction bearings. In the majority of cases the existing bearing housings cannot be re-machined for a proper application.

By installing pressure grease systems and by some change in the existing bearing design, Mr. Gray has found it possible to clean up and to materially improve the lubrication of the bearings. In the case of anti-friction bearings in steel plant auxiliaries grease is widely used as a lubricant. Various types of greases are available and care should be used in their selection. Lime soap products as well as greases compounded with aluminum stearate are used for lubricating equipment where moisture may be encountered and where operating speeds are comparatively low. High operating speeds and high temperature of operation usually call for the use of soda base greases which have higher melting points.

Where grease is used as a lubricant, it is essential that ample space be provided in the bearing housing, yet not so much room that the action of the bearing will throw the grease against the walls of the housing too far away for it to readily flow back to the bearing. Normally the bearing housing should be filled about half full. This permits the grease to expand without being forced past the closures. Relief fittings or suitable vent holes are highly desirable.

When applying grease to a bearing, particularly for the first time, care must be taken to assure that it is applied directly to the bearing and not merely placed in the housing. Provision should be made that too much grease cannot be applied to the bearings. This is especially true where automatic pressure grease systems are used. The requirements should be carefully studied and the feed and periods of application adjusted so that the bearing housings will not be filled full. Over greasing will cause churning, heating and waste.

Some auxiliary equipment requires oil lubrication. In the case of gear units, the mineral oil used on the gears is entirely satisfactory for the bearings. When oil is used, it is necessary to make the closures more elaborate than in the case of grease.

W. C. BAUER: In his paper, Mr. Gray indirectly points out the constant problem which confronts a lubrication engineer because the designer of the machinery is too engrossed with stresses and strains, performance, and space limitations of the machine to seriously consider how or why it is to be lubricated. The pressure grease systems which Mr. Gray has successfully substituted for black oil drip or wipe feeds are not new, and probably are as old in practice as the machinery to which they are now being applied.

In many instances, even very modern machines have been designed and so built that to the lubrication engineer at least ten different types of lubricants must be used if normal, trouble-free operation is to be secured. If ideal lubrication is to be accomplished, double this number of lubricants should be employed.

The internal combustion engine, particularly the type which uses blast furnace gas is the lubrication engineers' real headache. Again, this is a matter of correlation of design to lubrication. These engines invariably have water-cooled pistons which necessitate the use of some type of knee-action sliding joints to carry the water to and from the piston rod. Naturally, these joints are extremely difficult to keep tight, and hence there is almost universally a certain amount of water present in the lubricating oil.

As every lubrication engineer knows, when he is fighting high pressures and high temperatures on journals or sliding cross-head surfaces, the presence of even small amounts of water will aggravate the problem

exceedingly. Recognizing this trouble, the manufacturers of diesel engines are now designing their equipment with the substitution of oil cooling for the pistons rather than water cooling. Then, when leakage occurs in these sliding joints, there is no contamination of the lubricating oil by water and the lubrication troubles have been materially reduced.

It might be making a rash wish, but the writer of this discussion is very seriously hoping for someone to try to substitute oil cooling for the pistons on one of these big foundry gas engines in place of the water cooling now used. If the fight against water in the lubricating systems of these engines must continue, then means must be incorporated for the complete elimination of the water from the oil before it is fed back to lubricate the engine. There must also be some means employed to correct and remove from the oil the products of oxidation which occur in this oil due to high temperatures and pressures under which it is operated. The elimination of water from the oil will make the removal of these other contaminants easier, decidedly cheaper and more simple. An oil so corrected would undoubtedly greatly extend the operating periods between repairs and shutdowns on these engines.

G. F. BOWERS: Mr. Gray has described clearly the real progress that has been made in improving undesirable situations which have been encountered. The progress is a tribute to the thought and effort that has been given equipment that all too frequently is neglected.

The problems presented in the handling of the circulation oil for internal combustion engines are very complex. This is particularly true when it is remembered that in one plant the problem is one of increasing acidity while in another plant acidity may not be a problem but excessive contamination of the oil by dust, dirt and other foreign material, may be encountered. In other words, each plant presents a problem to be solved.

In the case of acidity it seems logical to assume that some place or places, in the system are local hot spots tending to rapidly oxidize the oil. Contamination from the cylinder oil, from the cooling water, and foreign material all complicate the problem. It follows, therefore, that only by a careful analysis of all the factors and by continual effort can the problems encountered in the circulating oil systems be solved.

The conclusions given by Mr. Gray are, in my opinion, of utmost importance, and represent the real aim of the lubrication engineer, namely, to use the mechanical devices available and the proper lubricants, to give the lowest total maintenance cost possible.

F. J. THOMAS: I would like to ask about the table on which the table roller bearings are lubricated with water. What provision was made to prevent the water from washing gear lubricant off the bevel gears on the drive end of the rollers? Was it a bevel gear driven table?

F. L. GRAY: Yes, it was a bevel gear-driven table. The water to the bearings was run into the grease hole in the cap, and circulated through the grooving of the bearings. The gears were not affected by the water used.

F. J. THOMAS: They were open type?

F. L. GRAY: Open gears, but we prefer to call them uninclosed.

W. H. MANDY: On these felts that you use in your crane bearings, you spoke of the maintenance being very low. I was wondering what maintenance is necessary. Are you running into incrustation of the felt, and do you have to take these felts out and wash them very often? If you do, with what do you wash them?

F. L. GRAY: When I speak about reduced maintenance, the reference is in comparison with wool waste and oil where daily inspections are necessary and oil additions frequent. With the felt lubricators we did not find that to be the case. In dirty spots, subject to mill dirt, it is good practice to occasionally remove and clean with a solvent, such as kerosene, which will work through the felt and flush out the dirt. It is then necessary to resoak them in the lubricating oil.

J. L. HAYNES: Mr. Gray is to be commended for having given us a very comprehensive analysis of the general lubrication and maintenance problem for the various equipment used in large steel mills.

Since the author states that his subject is confined to methods for reducing the operating costs for the older types of equipment, we understand why his paper deals chiefly with the problems which surround plain bearings as distinguished from roller bearings which are being applied more and more for new equipment.

As an engineer for a roller bearing manufacturer, it may be in order, therefore, for me, briefly, to contrast the maintenance and lubrication problems of roller bearing equipment with the older types of machines with plain bearings. This I shall attempt to do during this discussion.

It is interesting to note that pressure grease lubrication applied in the place of black oil for a three high pinion housing effected an improvement in bearing life of from 200 to 300 per cent. The economy in the quantity of lubricant used is understandable, but we are wondering if the change to grease would have produced such a considerable increase in bearing life if a good grade of lubricating oil had been used in the place of the black oil. Naturally, where there is a large waste of oil, the use of high grade oil would be too costly; but our thought is that since oil is almost always a better lubricant than grease for both plain bearings and roller bearings that this experience may be interpreted as a good demonstration of the poor performance we may expect with black oil lubrication.

On table roll bearings the chance for scale and perhaps water (near the roll stands) to enter the recess containing the saturated waste may be considerable, we believe, and the change to a solid cap with clean grease supply may have caused improvements due to the better sealing of the plain bearings. As we all know, good sealing is very important for roller bearing equipment, and the same is true of plain bearings although there are comparatively few installations with plain bearings where high grade seals are installed.

Since the so-called "one shot" type of lubrication system, some years ago, had earned for itself a rather poor name, we believe that Mr. Gray's success with "centralized control systems" should receive some special comment by him as any vital points in the de-

signs or use of these systems, which will insure success in operation, will be of interest to not only the men in the steel mills but also the builders of steel mill equipment and roller bearing manufacturers.

The technical literature contains a vast amount of data on the film action of oil in plain bearings. I believe that the most basic ideas for us to always keep in mind in connection with the action of oil in a plain bearing are that bearings operate best at speeds above the so-called critical range and that it is best to introduce the oil at a point away from the load zone and depend on the oil to adhere to the journal so as to be carried along into a wedge shaped film when it reaches the sector of the bearing which is in the plane of the load. This agrees with the practice followed by Mr. Gray in the use of a grease system.

When the speeds are very slow the journal will fail to carry the oil along to form a film under the load. Instead, the oil is either squeezed out of the bearing or wiped off from the journal so that you get metal to metal contact between the journal and bearing. Thus, the critical speed of a bearing is that speed which must be exceeded to insure good oil film action, and we judge that Mr. Gray's experience with grease bears this out although perhaps the critical speed for a given job may be different if you change from oil to grease.

In roller bearings there is no critical low speed problem and this accounts for the great saving in torque or effort required to set in motion roller bearing equipped cars, cranes, or other auxiliaries, compared to the older types with plain bearings.

We would be interested to know if Mr. Gray believes that a pressure grease system might give better performance on a very slow turning plain bearing than you could get with a good grade of oil as the oil would never get a change to form a proper film under the load, and the grease may be tenacious enough so that it is not squeezed out by the load. If grease under pressure were supplied directly in the load zone, it might cause the plain bearing to operate the best in the case of a very low speed installation as there would then be some lubricant right in the load zone even if it is not the most ideal kind.

While on the subject of pressure lubrication I would like to point out that such systems have no relation to the lubrication of roller bearings except where some pressure is required to transport the grease or oil to the bearings and introduce it into the housing against the pressure resistance of a check valve which is frequently used at the entrance to the bearing.

The film action that occurs between the rolling elements of a roller bearing is more analogous to the action between two gears than it is comparable to the lubrication of a journal. In the case of gears and roller bearings the lubricant reaches the working surfaces under no head or pressure, but is simply splashed or drained to the required points in the system.

Mr. Gray describes a job where the grease pump is directly connected, and then made to be motor driven. In other cases the use of hand feed is mentioned. We feel that more detailed accounts of the operating conditions that require a continuous supply of lubricant in some cases and for others where intermittent hand feed is sufficient would be of interest to many of us. I believe that any roller bearing job will be satisfactory with only very infrequent application of lubricant except perhaps those hot saws or cold saws where the speed generates heat enough to make a circulating cooled oil system desirable.

We are interested to learn of the success of felt pad lubricators for journals. This agrees with the good performance our company has had for many years in connection with our railroad journal boxes.

In these designs oil is used and a felt pad or wick with its lower end always dipping in the oil serves to perfectly lubricate the end of the axle which takes the side thrusts on curves, etc., against a bronze plate or block mounted in the cover of the box.

Our experience with the great superiority of two hardened steel members to resist wear checks well with Mr. Gray's statement regarding the pig machine using hardened wheels.

I believe that in many cases part of the advantage of hardened steel is derived from the fact that it not only resists abrasion, but it is also able to carry very heavy concentrated loads without crushing or cutting, so when mechanical irregularities cause excess pressures to be concentrated on limited areas, the hardened steel will survive where other materials crush or pound out.

I hope that Mr. George Bauer won't mind if I refer to the group of 100 eight-wheel roller bearing equipped ingot cars which he designed in 1935 or 1936, and which, I believe, have given about 100 per cent service for four years at the Gary Works. These have a pair of hardened steel thrust plates for each bearing.

I shall not attempt to discuss the latter part of Mr. Gray's paper dealing with internal combustion engine problems as we lack the experience necessary to cover this subject.

The conclusion of my discussion is that men like Mr. Gray who have spent many years studying at first hand all the diseases of machinery that are related to lubrication are not heard from often enough. They should be called in for advice more by the designers of new equipment so as to make use of their experience and knowledge in connection with bearing design and best methods of lubrication. Such coöperation will help to keep costs down and improve the life and performance of our equipment.

F. L. GRAY: I agree with Mr. Haynes in practically everything he brought out. We would like to substitute roller bearings in a lot of these cases, but the easier way has been taken. In substituting a better oil for black oil without making a major change-over, we would still have high oil usage, and it is costly to waste oil that way, so grease is used.

We have applied grease through a pressure grease system to a slow moving roll with success. On our sheet bar mill with open window lubrication, the bearings were changed several times each turn in order to hold the section. With an automatic system, the bearing life was extended to six weeks. That was an improvement. However, with the application of non-metallic bearings, a life of 21 months was recorded. If the same corrections were made in the babbitt bearings with a proper lubricant, properly applied, I still think that the non-metallic bearings would be less outstanding. When non-metallic bearings are recommended for a job like that, you also note the requirements which are emphasized for this bearing. If we can do that on an old type bear-

ing, with proper oil or grease lubrication, we will get comparable results.

E. S. GLAUCH: I noted with considerable interest Mr. Gray's reference to the use of graphite inserts on brass bearings on several applications where temperatures exceeded 450 degrees F. There is no question but that on many applications of this type in steel mills brass bearings with graphite inserts can be used to good advantage, as there is no grease that will withstand temperatures constantly over 500 degrees F. Our company produces a material known as graphite lubricating rods which are supplied in various diameters for the manufacture of such bearings.

These rods are now being supplied to some steel companies that make up their own replacement bearings; the graphite lubricating rod is usually supplied in standard lengths of about 12 in. long, and can be cut to any length required for the bearings. This material can be used for applications where unusually high temperatures exist, where there is a full rotation of the shaft or journal. They can also be used in applications where lubrication is difficult, and often neglected.

Mr. Gray also referred to the use of non-metallic moulded type bearings, heavy duty service on hot metal cranes, bearings being grease lubricated. He states that after eight months of operation in an atmosphere of graphitic carbon from the pouring of hot iron not more than 35 per cent wear was shown, and that the graphitic carbon acts as an abrasive on metallic bearings which causes excessive wear. He states that on the non-metallic bearings it works into the fabric and forms a glazed surface.

I would like to emphasize that this graphitic carbon referred to, which is sometimes referred to as blast furnace graphite or "kish" cannot be and should not be confused with lubricating graphite. This type of graphitic carbon or graphite that comes from the hot iron contains a very high percentage of iron and that is the reason it is abrasive on metallic bearings. Of course, on the moulded type bearings it acts as Mr. Gray has stated—it embeds itself in the bearing, and thereby does not cut the bearing itself.

ANTI-FRICTION BEARINGS

(Continued from page 39)

based on 10 years minimum bearing life; the cranes that follow under each classification; the rpm. of cranes under each classification divided into low, medium and high speed and the box load in pounds for each bearing. This box load is tabulated from 1000 lb. to 100,000 lb.

The various manufacturers of anti-friction bearings were then asked to specify the particular bearings that they would recommend for the different services tabulated. The bearing tabulation shown gives information covering all the services for steel mill cranes, both bridge and trolley track wheel axles. From this bearing tabulation it is possible to select a recommended bridge or trolley track wheel axle bearing for any crane and type of service shown on the data sheet. A total of approximately 1600 bearing listings are shown on this tabulation sheet which covers a wide range of service and sizes. It is not to be implied that this great number of bearing listings involves a large stock of bearings for servicing cranes. It will be noted that many types and sizes of bearings are applicable to a large number of cranes.

Test data for working hours includes the time when any motion of the crane was actually operating, whereas the bearing life is based on full load, full speed operation. The bearing ratings are therefore conservative.

The condition of crane runway and the deflection of track wheel axles also affect the life of bearings, but these are a matter of proper design and maintenance, and are not allowed for in the table. The classification offered will serve as a guide, subject to local working and service conditions.

H. W. NEBLETT, *Chairman*
H. W. BALL
R. N. THOMPSON

MOSES DISCUSSION

(Continued from page 37)

time being this will be taken up later for further experimentation.

Regardless of the method used in groove construction it is suggested that the greatest single difficulty will be found in roughened groove surfaces of the roughing rolls and principally in the first two or three ovals. No mention has been made of roll materials but some representatives of roll makers present are familiar with our strenuous efforts to obtain a roll material whose groove surfaces will be longer lasting without the existing rapid roughening in the slowly revolving stands.

Either system of pass layouts will produce a good upsetting quality rod from an initially good billet surface provided that smooth and unpitted groove surfaces are used and without any finning or lapping present. Previous experience with the damaging effects of these latter must be discounted entirely because even very slight overfills will cause a minute seam. In the rolling of this grade of product the established roll costs, as well as mill expense as affected by roll change time, must be thrown overboard, at least at this writing.

SINTERING of IRON ORE

By E. W. Shallock

Chief Engineer

AMERICAN OIL RECLAMATION CO.

CHICAGO, ILLINOIS

Presented before A. I. S. E.
DETROIT SECTION, March 11, 1941

▲ IN the sintering process a quantity of fine ore, or a quantity of flue dust, or a mixture of both, together with a small amount of coal or other fuel, is first moistened with water; then the mixture is spread in a layer on the grates of a sintering machine. The top of this layer, or bed, is then ignited and air is drawn down through it so that combustion is carried on down through the bed. During this process a high temperature zone, the actual sintering, travels through the bed and when it reaches the grates at the bottom, the process is completed.

Sufficient heat is developed in the burning of the fuel to bring about fusion of most mineral particles which causes a re-combination of the iron oxides and the crystalization of the mass into a new form called sinter.

The sintered product is ideal material for charging into a blast furnace becuase it is porous and, for that reason, presents an enormous area to the reducing gases of the furnace. It is free from moisture and, therefore, requires less coke for its reduction. Because it is free from fines, it distributes itself better in the furnace and prevents channeling.

A blast furnace is charged with ore, limestone, and coke and, in supplying the necessary air for the smelting of the ore, large quantities of dust are created and blown out. This dust is caught in dust collectors and is called flue dust. Before sintering came into general use, this dust was usually re-charged or else wasted or used for filling.

Through the large scale use of iron ores from the Mesabi range in Minnesota, large blast furnace losses through flue dust began. These ores were cheap and easily mined and were, therefore, used in ever-increasing proportions, even though the furnace operators did not like to use an ore so largely made up of finely divided particles. Owing to the fineness of the ore, the furnace charge descended in irregular movements. These movements are known as slips which eject from the top of the furnace large quantities of flue dust which is chiefly fine ore and fine coke. This loss was in addition to the regular amount of flue dust carried over with the gases in the normal operation of the furnace and, of course, as the amount of fines increased, the amount of flue dust produced increased. Also, as the fines increased, the amount of coke needed per ton of pig iron production increased.

Flue dust losses in the great central steel producing district can be roughly taken as about 200 lb. of dust per ton of pig iron produced, while it has been reported that some plants averaged as high as 800 lb. per ton of pig iron.

It is safe to say that for about 20 years up to 1920, the annual flue dust production was in the neighborhood of 2 million tons. The average iron content was about 40 per cent, which in metallic iron would be 800,000 tons per year.

In many cases it was attempted to re-use this dust by simply wetting it and then re-charging it. Most furnace plants dependent on Lake Superior ore made persistent efforts to thus re-use raw dust. The results varied and were the subject of many disputes for years but, even with the most favorable practice, the iron yield did not show more than a slight smelting of the iron in the returned dust. Flue dust production was increased as the raw flue dust was re-charged with greater furnace irregularities and increased fuel consumption.

This, then, gradually led most operators to agree that

flue dust cannot be successfully re-used as raw flue dust and that the practice did not pay.

In the meantime, however, sintering began to take hold and operators—realizing the iron value of the flue dust—began stock-piling it for future use in sintering plants.

The first iron flue dust sintering plant began operations in 1911. It used a very small machine which was capable of producing about one hundred tons of sinter in 24 hours. By 1917 there were 50 units of this size in 28 different furnace plants. About that time larger machines were developed which had a capacity of about 300 tons per day. From that time on, there was a rapid development in still larger units. One unit in operation today has produced 1850 tons in one day.

In this country alone more than 80 sintering plants have been built and if all of these plants were operating, they could produce about 15 million tons of sinter per year. Today almost all of the stockpile flue dust has been sintered and the sintering of current production flue dust is quite general.

The sintering of ore was also a gradual development. Most flue dust contains more carbon than is necessary for sintering. Excess carbon also slows up the sintering rate. In order, then, to take care of the excess carbon and also to increase the sintering rate other carbon-free materials were mixed with the flue dust. This, then, led to adding fine ore to the flue dust—it being argued that if fines produced flue dust which then had to be sintered, why not sinter the fines first and thus not only increase the capacity of the sintering plant but also increase the furnace yield. This practice of mixing fine ore with flue dust also resulted in a much better quality of sinter.

Soon more and more fines were being used and where there was not enough carbon in the dust, additional fuel had to be added.

Plants were finally built which sintered nothing but ore mixed with fine fuel. One of these plants was located at the mines where it sintered high moisture ore and where the elimination of water in the ore resslted in a freight saving which almost paid the sintering cost. As this ore sintering developed, it was necessary to design larger and larger units.

Another development was the demand for better sizing of the raw ore in order to get better distribution and more uniform gas contact in the blast furnace. This, then, resulted in the building of crushing, screening, and sizing plants. An interesting paper on this subject is published by the U. S. Department of Commerce, Bureau of Mines. It is technical paper No. 459, called "Effect of Sized Ore on Blast Furnace Operation" by S. P. Kinney. In it there is a graph which shows that when the ore was not sized, the coke consumption per ton of foundry iron was 2713 lb. and an average of 280 tons of iron was produced. When two sizes of iron ore were used, the coke consumption was 2402 lb. and 337 tons of iron were produced. This is an increase of 57 tons of iron and a decrease of 311 lb. of coke per ton iron. When three sizes of ore were charged, there was another improvement; the coke consumption was 2225 lb. per ton of iron and the yield was 360 tons per day. Where three sizes were charged, there was a coke saving of 488 lb. or 18 per cent and production increase of 80 tons or 28.6 per cent.

In Europe there are several furnace plants where most, or all, of the ore is crushed, screened, and sized and in which the fines are sintered. One of these plants has a capacity of 3600 tons.

Crushing, screening, sizing, and sintering of ore has been practiced in Germany for some time. For a long time it had been debatable if, in view of the low iron content of their ore, it would be economical to go to this sort of preparation, but on the basis of experiments, it was proven that it would pay to crush and sinter even this low grade ore on the basis of coke savings and greatly increased furnace yield. Some figures from one such plant are very interesting. In the first period ore was charged without crushing or sintering. In the second period some of the ore was put through a crusher but it was not screened and no sinter was charged. In the third period, the crushed ore was screened and a small amount of sinter was charged. In the fourth period all of the ore was crushed and screened and the fines were sintered—charging about 35 per cent sinter. In the fifth period all the ore was crushed and screened and the fines sintered, charging about 52 per cent sinter. In the sixth period only crushed screened ore and sinter were charged and the percentage of sinter was increased to 59 per cent. The results obtained make very interesting reading. In the first period when the ore was not crushed or screened or sintered, the yield was about 30 per cent. Pig iron production was 180 tons and coke consumption was 2750 lb.

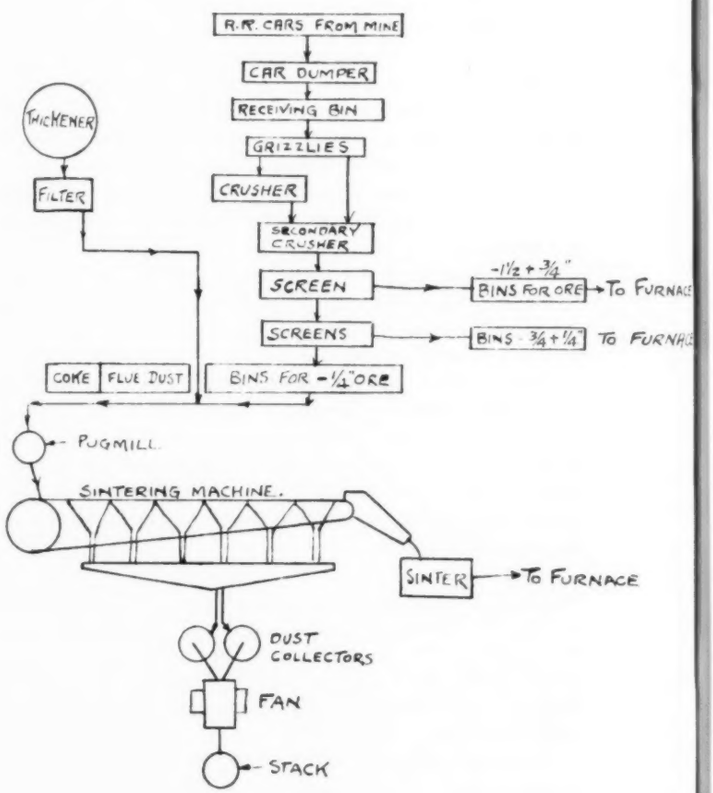


TABLE I

	Material charged	Per cent sinter charged	Pig iron, tons	Per cent increase	Coke used lb. per ton of iron	Per cent decrease in coke	Flue dust, lb. per ton of iron
1	Ore Not crushed Not screened	None	180	..	2750	..	538
2	Ore 60% crushed Not screened	None	200	11	2640	4	358
3	Ore 90% crushed and screened	4.8	220	22	2310	16	...
4	Ore 95% crushed and screened	35	280	55	2200	20	...
5	Ore All ore crushed and screened, fines sintered	52	290	61	2090	24	...
6	Ore All ore crushed and screened, fines sintered	59	300	66.5	1925	30	105

In the second period when about 60 per cent of the ore charged was crushed but not screened and when no sinter was used, the production was increased to 200 tons or 11 per cent increase and the coke decreased 110 lb. or 4 per cent.

In the third period when about 90 per cent of the ore charged was crushed and screened and when about 4.8 per cent sinter was used, the pig iron production increased to 220 tons or 22 per cent increase and the coke decreased 440 lb. or 16 per cent.

In the fourth period when 95 per cent of the ore was crushed and screened and when 35 per cent sinter was charged, the production increased to 280 tons or a 55 per cent increase and the coke decreased 550 lb. or a 20 per cent decrease.

In the fifth period when all of the ore was crushed and screened and when 52 per cent of the charge was sinter the pig iron tonnage increased to 290 tons or 61 per cent and the coke decreased 24 per cent.

In the sixth period all of the ore was crushed and screened and the fines were sintered. The furnace was charged with 59 per cent sinter. The pig iron production increased to 300 tons or 66½ per cent and the coke decreased 825 lb. or 30 per cent. Table I shows these figures tabulated for easy reference.

The flue dust production figures are also very interesting. Before crushing and screening the ore, the flue dust production amounted to 538 lb. per ton of pig iron. After the ore was crushed and screened, the flue dust production was reduced to 358 lb. or 33 ⅓ per cent. After crushing, screening, and sintering, the flue dust production was 105 lb. per ton of pig iron, or a reduction of 80 per cent.

Additional benefits derived from this ore preparation were better pig iron uniformity, more efficient stove heats, and regular blast furnace performance so that typical disturbed performances which had prevailed before became a rarity.

In this country there is one plant under construction which is designed to crush and size all of the ore going to the furnaces. The fines will be sintered together with the current production of flue dust in a sintering plant which will have a capacity of about 4000 tons of sinter per day. This will make it the largest sintering plant in the world.

In order to present a rough idea of the magnitude of such a plant the following data is of interest: Roughly, about 300 cars of ore will come into the plant every day. These cars will carry about 13,000 tons of ore. One hundred cars of sinter will go out every day, carrying about 4000 tons of sinter. About 200 cars of sized ore will leave the plant every 24 hours.

In this plant there are about 7500 ft. of belt conveyors and a total connected horsepower of about 6500. This horsepower is about equally divided between the sintering plant and the crushing plant.

The ore is dumped into the crushing plant through a rotary car dumper which dumps two cars at a time over grizzly bars into two gyratory crushers. From these crushers the ore travels by two belt conveyors to four secondary crushers. From the secondary crushers belt conveyors take the ore to a screening tower where it is discharged over six screens. Here three sizes are made. The large size or about 1½ in. is taken by belt conveyor to a bank of storage bins. The middlings, or ¾ in., are taken by another conveyor to a second bank of storage bins. The fines, or minus ⅜ in., are taken by belt conveyor to a third bank of storage bins.

The flue dust and coke breeze are unloaded in a track hopper from which they are taken by belt conveyor to a screening and crushing station. From this station another belt conveyor takes this material to a fourth bank of storage bins. Fine ore from the third bank of bins, and flue dust and coke from the fourth bank are used to make up a desirable sintering mixture which is collected on belt conveyors which take the mixture to a superhopper. From the superhopper the material is fed into pugmills where the mixture is pugged and moistened. From the pugmill, it travels by belt conveyor to a swinging spout which, in turn, spreads the material on the grates of the sintering machines. The sinter is discharged into railroad cars.

The two sizes of ores are drawn from their storage bin in desirable blends and are taken by belt conveyor to a loading tower where the material is discharged into railroad cars as needed.

There are many reasons why it is desirable to sinter ores aside from desirability of obtaining better distribution in the furnace and this then raises the question as to what ores should be sintered. Roughly, a few classifications are—

1. Ores of such fineness that the ratio of metallic iron charged to the iron smelted becomes a doubtful element which results in abnormal fuel ratio in the furnace.

2. Ores of such high sulphur content as to influence sulphur content in the iron.

3. Ores of such high combined water content that the expulsion of combined water in the hot zones causes unnecessary fuel consumption.

4. Ore of such large size that crushing and sizing is

necessary in order to get uniform distribution in the furnace.

5. Natural ores of such high moisture and combined water content, yet sufficiently low in gangue that they are in a prohibitively penalized class of ore price schedules.

6. Ore carrying such high moisture and combined water content and of such location that prohibitive freight costs are incurred in their delivery to the consumer.

7. Carbonate ores whose CO_2 content exacts prohibitive freight charges on iron content to the consumer.

8. Ore which must be ground to remove gangue and undesirable constituents in order to raise the grade and in which such grinding produces fines which cannot be used in the furnace.

9. Ore which must be ground very fine in order to remove the iron from some other valuable mineral and in which flotation may be used to make the separation.

10. Ore which may be too large in size and in which there may be a very great chemical variation. Here, crushing, sizing, and sintering is used to bring about a uniform blend as well as to provide a better and more uniform physical structure.

Recently sintering plants have been making a type of sinter which is used in the open hearth where it replaces what is known as the charge ore. In making this open hearth sinter, a mixture of ore, roll scale, and flue dust is used. Either hard coal or fine coke may be used as fuel. The sinter will average about 65 per cent Fe. Due to the presence of roll scale, the sinter is high in iron and the yield of the sintering machine is greatly increased.

A sintering machine which will produce 300 tons per day on flue dust should produce about 370 tons on ore and, flue dust and about 420 tons on a good open hearth mixture. This type of sinter probably has no benefits over good lump ore, but should have many benefits over plastic ores used for the same purpose. It has little or no moisture. It has no combined moisture. It has a greater specific gravity than plastic ore if the proper low porosity open hearth sinter is produced.

When fine ore is mixed with flue dust, it increases the capacity of the sintering machine because the ore is coarser than flue dust and, therefore, it opens up the bed and increases its porosity. This, then, brings up the question of particle size of the ore to be sintered.

In screening the ore, the size of the openings in the screen depends largely on the character of the ore and its moisture content. Obviously, high moisture ore will require much larger screen openings than low moisture ore. In general, a screen with $\frac{3}{8}$ in. slotted openings is used. In some plants much larger openings are used. Larger particles do not retard sintering; on the contrary, they aid in sintering in that they increase porosity. While pieces as large as $\frac{3}{4}$ in. and one inch in size will not completely sinter, they will combine themselves with the sinter and sintering will remove any moisture that may be in the ore.

Ore also plays a very important part in the life of grate bars in sintering machines. If the carbon in a bed is too high, the temperature in the sinter bed will be too high and the life of the grate bar will be short. In ore sintering carbon content can be closely regulated to the exact amount required for good sintering. One of the characteristics of fine fuel in an ore mixture is that in proportion to particle size more fuel will adhere to the finer pieces than to the larger pieces of ore. This is an advantage in that the coarse particles, with little carbon, roll to the grate where carbon is undesirable and the fine particles with more carbon remain at the top of the bed where it is desirable to start ignition. With the minimum of carbon on the grates, their temperature is low and, consequently, their life is longer.

A sinter bed with ore which is fairly coarse will be much more porous than one with an ore which is uniformly fine. With a coarse ore, then, a much deeper bed can be carried on the sintering machine. This, in turn, results in a much slower sintering machine speed with a much longer life for the pallets, the grate bars, and the suction fan.

In conslusion, then, it has been proven that good strong porous sinter is more desirable than the best ore in this country because it makes possible a greater production of pig iron, because it lowers fuel consumptions, because it distributes itself better in the furnace, because it provides a more intimate and greatly increased gas contact, because it decreases flue dust production, because it prevents channeling and slips. and because it greatly improves quality and uniformity of pig iron.

DISCUSSION

PRESENTED BY

A. J. F. MacQUEEN, *Superintendent of Maintenance*, Rotary Electric Steel Company, Detroit, Michigan

E. W. SHALLOCK, *Chief Engineer*, American Ore Reclamation Company, Chicago, Illinois

E. A. ROHRIG, Detroit Edison Company, Detroit, Michigan

S. P. OSGOOD, *Appropriation Engineer*, American Steel and Wire Company, Cleveland, Ohio

C. P. BETZ, *Assistant Manager*, Blast Furnace Division, Great Lakes Steel Corporation, Ecorse, Michigan

L. S. VOIGT, *Master Mechanic*, Coke Plant, Great Lakes Steel Corporation, Ecorse, Michigan

E. J. McCLEARY, *Manager*, Blast Furnace Division, Great Lakes Steel Corporation, Ecorse, Michigan

W. H. COLLISON, *Superintendent*, Coke Plant, Great Lakes Steel Corporation, Ecorse, Michigan

R. L. SCHOLZ, University of Toledo, Toledo, Ohio

JOHN HEALD, *Sintering Plant Foreman*, Great Lakes Steel Corporation, Ecorse, Michigan

A. J. F. MacQUEEN: There are a couple of things I would like to know about sintering. For one thing, what sort of fuel is used to carry on this process, and does it make much difference; in other words, is the process critical to the fuel used or the kind you have? Could you give us a little detail on that angle?

E. W. SHALLOCK: In sintering flue dust, the fuel is right in the flue dust because it consists of coke and

ore that are originally charged in the furnace. When there is a deficiency of fuel in the dust extraneous fuel is added. It doesn't make much difference whether it is coke or soft coal or fine coal. I would rank coke first and hard coal second and soft coal third. Does that answer your question?

A. J. F. MacQueen: Has this process been used or applied to the point where you can use grindings or fine machine shop turnings—anything of that sort?

E. W. Shallock: I don't know that it has been used to sinter such materials by themselves, but they do use such materials and mix them with ore and flue dust and sinter them in that way.

E. A. Rohrig: I would like to know if the natural impurities that occur in the ore, anything like phosphorous and sulphur, are reduced?

E. W. Shallock: The sulphur content is very greatly reduced. That is, you could have an ore with 7 or 8 per cent sulphur and you could reduce that to about .015.

E. A. Rohrig: That would be quite an advantage. Did you say that 200 lb. to 800 lb. of dust is recovered per ton of ore charged?

E. W. Shallock: I said that on an average, perhaps 200 lb. per ton of pig iron would be recovered, but there have been cases where it has been as high as 800, although I believe that is a rarity.

S. P. Osgood: What is the operating cost of the sintering machine?

E. W. Shallock: It varies anywhere from 40 cents to $2.50, depending on the kind of bookkeeper you have.

C. P. Betz: Mr. Shallock, in talking about fuel, you no doubt refer to the carbon in the mixture you are sintering. What is the desirable percentage or does it vary?

E. W. Shallock: There is quite a variation in the amount of fuel used; it depends largely on the character of the ore—whether it is high in moisture, whether it is low in moisture, and it will depend on the fineness of the fuel. The finer the fuel, the less fuel needed, because when the fuel is fine it distributes itself much more in the bed and therefore you utilize every particle of fuel.

C. P. Betz: Naturally, the fuel that is most commonly used in the sintering of ore is coke breeze. How fine is the coke breeze; would it be as fine as ¼ in.?

E. W. Shallock: It should be finer than that. If possible it should pass through ⅛ in.

C. P. Betz: Can you successfully screen coke breeze through ⅛ in.?

E. W. Shallock: It depends, again, on moisture.

C. P. Betz: Do you have to dry the coke breeze?

E. W. Shallock: Yes, I would say if you would want to get it all through a ⅛ in. screen you would have to dry it.

C. P. Betz: Then provision should be made in a sintering plant for a coke breeze drier and screen.

L. S. Voigt: What proportion of sinter can be used in the furnace burden?

E. J. McCleary: I tried 85 per cent once, and I got into quite a lot of trouble.

E. W. Shallock: There are some furnace plants that use all sinter, you know.

E. J. McCleary: Where?

E. W. Shallock: The Chataugay Ore and Iron Company used 100 per cent sinter at one time.

Member: Didn't Birmingham use that?

E. W. Shallock: No, sir. Birmingham is going to use about 28 per cent.

E. J. McCleary: Isn't that Port Henry?

E. W. Shallock: No, Port Henry was the old Wetherby Sherman Company.

E. J. McCleary: What kind of practice did they have?

E. W. Shallock: I don't know that.

W. H. Collison: I would like to ask if Mr. Shallock could explain exactly why it is necessary to moisten the charge.

E. W. Shallock: The only reason for moistening the charge is to bring about porosity. Thus, in moistening, you get the particles to form tiny pellets and those tiny balls in that way bring about the pores in the bed that allow the air to get through. If a bed is too dry, it won't have pores and it won't ignite.

C. P. Betz: I have been told that you cannot successfully use all sump breeze. That is very fine.

E. W. Shallock: Yes, it is.

C. P. Betz: Haven't you heard of anyone having trouble with sump breeze?

E. W. Shallock: There might be trouble in feeding it because of its moisture but it shouldn't be a bad sintering fuel. In fact, I think sump breeze is a good material to use because, as I understand it, it is fairly uniform in size; isn't it? There isn't any great variation in sump breeze.

C. P. Betz: It is very fine.

E. W. Shallock: Then it would be a good fuel.

R. L. Scholz: Is the sintering process a batch process?

E. W. Shallock: There are several systems of sintering. One is the continuous system in which the process is continuous and the other one is the batch system or intermittent system of which there are several kinds.

R. L. Scholz: How does the batch process compare with the continuous process?

(*Please turn to page 73.*)

Comparison of SOAKIN PI

Presented before A. I. S. E. ANNUAL CONVENTION
CHICAGO, ILLINOIS, SEPTEMBER 24-27, 1940

By
YOUN
YOUNG

▲ MANY operators of blooming mills today find the class of product they are now making has changed to such an extent from their previous practice that their soaking pit equipment is no longer adequate to supply ingots to their mill at a sufficient rate to maintain the desired continuity of rolling practice. They have experienced a steady increase in the demand for hot top and large slab ingots to such an extent over their previous requirements that in some plants the blooming mill production has not been able to meet the increased demand. This has come about through a lack of heating capacity to meet the changes in rolling practice, ingot size and shape; to an increase in the percentage of this class of ingots over their former practice, which in most cases consisted of open top ingots of a size that were satisfactorily handled with the existing equipment.

Ingots which formerly could be rushed to the soaking pits shortly after the heat had been poured have been replaced with ingots that now must be held at the pouring floor undisturbed for a period of from 2 to 4 hr.

In addition, the delay due to the time required to remove the hot tops and the very appreciable increase in time required to strip and charge big-end-up ingots in the pits have resulted in ingots delivered to the pits at an appreciable lower temperature, requiring more time to heat.

The purpose of the soaking pit is to receive ingots from either the open hearth, bessemer, or stock and through the application of heat to properly prepare them to secure the continuity of rolling mill operation and metallurgical qualities necessary for good practice.

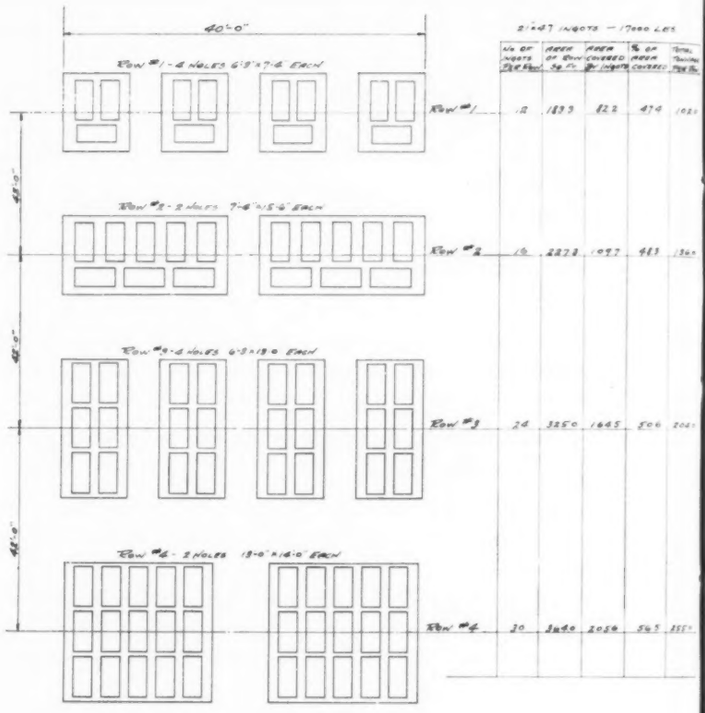


Figure 1—Chart showing relation between soaking pit size, ingot size, and pit capacity.

To measure the soaking pit capacity to meet these requirements requires an analysis that includes the pit size, the ingot sizes, class of ingots, and the heating time necessary to maintain rolling mill schedules.

To maintain continuity of mill operations there must be sufficient heating capacity to provide the ingots at the rolling rate of the mill. This requires that if continuity is to be maintained on all sizes, the pit capacity must equal the rolling rate multiplied by the time the ingots are in the pits.

For example, on a given size, if the mill can roll 25 ingots per hour, and the average pit time from charge to charge is 6 hours there must be an average of 6×25 or 150 ingots being heated during the 6 hours. If the average heating time is 8 hours, then 8×25 or 200 ingots must be heated during the 8 hours to maintain continuity of rolling mill operations, or the continuous heating capacity must be either 150 or 200 ingots for the above heating periods.

Therefore, any change in size or class of ingots that increases or decreases the time required to heat the ingots affects the capacity of the pits to maintain continuous rolling operations.

Having determined the number of ingots required for continuous rolling mill operations and the number of ingots of the various sizes to be heated per hour to meet the proposed schedule of operations, it then remains to determine the size and number of pits required.

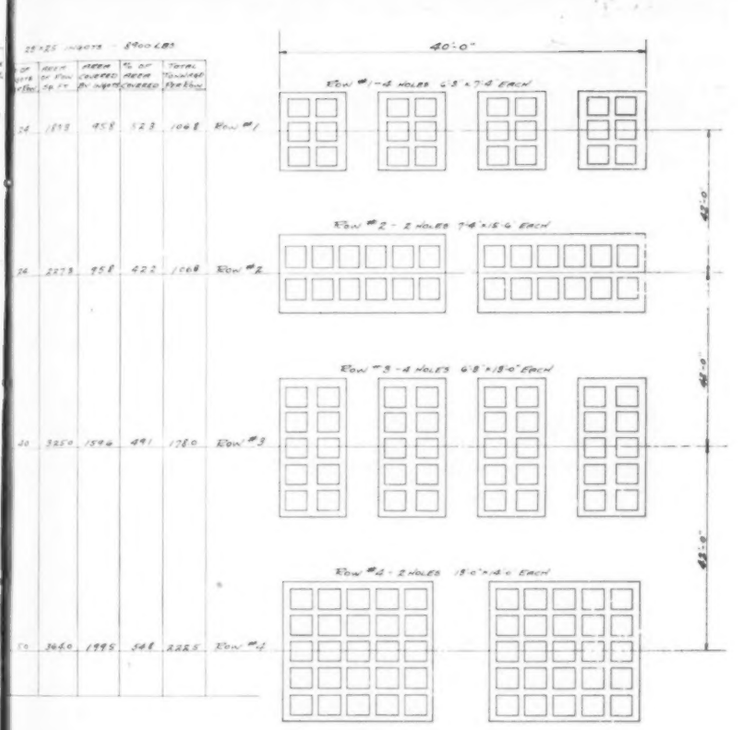
The size of the pits will be controlled by the size of the ingots, and a layout for the loading for the different size ingots will determine the most desirable arrangement to secure the proper distribution for good heating, in the space available.

The number of pits required is a function of the pit design, the supply of ingots and rolling rate which is usually based on an 8 hour turn.

For slab heating only, the selection is usually quite simple, but when a variety of sizes and classes of ingots are rolled, a detailed analysis is required to determine the number and combination of pit sizes to secure the best practice. Where the size of ingots varies widely from maximum to minimum, the best results can usually be obtained with a variation in pit sizes. When the rolling rate exceeds the rate of supply of ingots, resulting in intermittent turn operation, economic considerations will affect the final decision.

IN PIT Designs

By F. E. Leahy, Fuel Engineer
YOUNGSTOWN SHEET & TUBE COMPANY
YOUNGSTOWN, OHIO



As a special case, heating a relatively large number of small sized ingots in a large pit can be used to illustrate one factor that will affect the selection of the pit size, and that is where there is insufficient heating capacity to provide for an 8 hour rolling period.

Assume that the pit will hold sufficient ingots for a one-hour rolling period, and that the pit can be charged in approximately one-half or less of the drawing time. Also, at the time the ingots are ready to draw from the pits a heat of ingots arrives hot and ready to charge. If it is to be charged into this pit, it will then have to stand one hour on the track plus the time it takes to charge, thus losing heat, and prolonging the time required to bring the ingots to the proper temperature for rolling.

If the rolling operations are planned not to exceed 8 hours duration, then there would be two drawing periods and one charging period during the turn, leaving 5½ hours for heating. If the ingots arrive in time and in condition to permit heating in this time, the pit will be able to double; if not only one full charge can be drawn from the pit during the 8 hour rolling period.

On the other hand, if there are available a number of smaller pits of equal heating capacity, each pit may be charged as soon as it is emptied, proportionally reducing the time the heat is held on the tracks thus lessening the time required to condition the heat for rolling. Under heating conditions where it is necessary to double from some of the pits, this will be a factor in the selection of the pit size.

However, if the rolling rate greatly exceeds the ingot producing capacity and rolling operations are in consequence intermittent, it is desirable to have the maximum number of ingots ready before rolling commences, in order to obtain the minimum rolling time.

To get the maximum heating capacity in the space occupied by the smaller pits it is necessary to increase pit size over that formerly in use. Also, with increase in pit size, the less is the loading capacity affected by variations in ingot size. With larger pits the method of operation can often be adjusted to suit the rolling demands in the way of time by charging to the correct per cent of full loading. In this way the required supply of ingots may be provided for the mill, permitting operations to be carried out under ideal conditions for rolling. By proper scheduling and timing of the rolling mill and steel producing operations, the maximum production with a given soaking pit installation will be obtained.

In general, relatively large soaking pit holding capacities are desirable for intermittent operation and for storage of surplus ingots during mill delays, but the value decreases with increase in continuity of rolling mill operations.

CLASSIFICATION OF INGOTS

Ingots may be generally placed under the general classification shown in Table I.

TABLE I
Ingot Classification
Variation in size, inches

	Squares		Rectangles		Slabs		Rounds	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Hot top	30x30	24x24	28x32	24x26	28x56	21x40	23	18
Bottle top	..	..	23x24	20x22	28x56	21x40	..	..
Open top	31x31	22x22	28x32	24x26	28x56	21x40	..	25

There are few plants that cover this full range of sizes so that soaking pit installations will vary depending with the size of ingots to be heated and the finished size. With a variation in size of ingots as listed in order to meet rolling mill and ingot capacity, a very careful analysis is necessary to secure the most economical and efficient pit installation for the best practice.

A representative list of ingot sizes and rolling rates for one plant is as given in Table II.

From the above the tons of ingots per hour will vary

from 134 to 182 depending on the size of ingots being rolled, and the elongations.

To provide the required soaking pit capacity it is now possible to select from any of the following:

1. Rebuild existing regenerative type pits to more closely adjust their size to the ingot size.
2. Apply automatic temperature, combustion and reversing control to above.
3. Replace any or all of the manually operated regenerative type pits with any of the following designs:
   a. The Rust automatic regenerative type pit.
   b. The Isley regenerative, semi or fully automatic type.
   c. The Chapman-Stein one-way fired recuperative type.
   d. The Amsler-Morton center fired recuperative type.
   e. The Salem circular tangentially fired type.

The above designs utilize different constructions, principles of combustion and heat transfer that should be carefully analyzed to determine the most applicable for the fuels available, and the size and class of ingots to be conditioned.

The regenerative type, the pioneer soaking pit, was designed particularly to utilize producer gas when the demands in the way of quality were quite simple to meet and the principle requirement was capacity. Practically all ingots were either open top or bottom poured so that the pits were able to meet quite successfully the requirements at a satisfactory cost.

Where natural gas was available at a comparable cost with producer gas, this fuel was used by firing through the arches of the checker chamber closest to the pit and both chambers were used to preheat the air.

The advent of the by-product coke plant as an integral part of many steel plants provided a surplus of coke gas that became available for use in the soaking pits and this was used to replace the producer gas to the extent that today it is utilized in most of the larger steel mills. Coke gas, in most installations, is fired through the arches; in others it is brought up through ports in front of the former gas checkers.

Another method quite promising is to fire through a reforming tube. This is usually constructed with a refractory tube passing through the furnace air checker chamber near the top of checkers and opening into the checker previously used for producer gas. The gas is partially burned in this tube with a deficiency of air, with the heat from the air checker chamber applied to the outside of the tube in which a reforming action takes place so that gas issuing from the tube into the checker chamber is at a lower heating value per cubic foot than the original gas. By regulating the deficiency of air to the gas burning in the reforming tube the desired heating value of the reformed gas may be obtained. This may be used to advantage when the fuels are either coke, natural or refinery still gas. The effect is equivalent to that obtained from a lean gas. This may be used where recirculation of the burned gases are either difficult to secure or cannot be obtained.

The regenerative pits have been successfully fired with the fuels available in steel plants today and probably are used for heating the largest percentage of the total ingots rolled today.

In general the standard practice was to install from 6 to 8 rows of four pits per row and most of the original pits were rectangular in shape varying from 6 to 7 ft. in either direction. As the ingots, except slab ingots for plates or forging, were relatively small and were charged usually in a short time after pouring, they could be conditioned for rolling in a shorter time than now required, and provide ingots at the rate then required for the rolling mills. The heat input demands in some cases did not greatly exceed the radiation losses which at this period were comparatively high as insulation was seldom used on soaking pits.

With a change in class of product and ingot size in place of that for which the pits were originally designed, the capacity was immediately affected, and a change in size required to meet the new demands.

The possibilities of increased heating capacity through a change in size of regenerative pits may be seen from the following installations rebuilt in recent years:

At one plant the original installation of one row of four pits each 7 ft. 4 in. x 6 ft. 3 in. was rebuilt and enlarged to a row of four pits each 13 ft. 0 in. by 6 ft. 3 in. Heating 21 in. x 47 in. ingots the original row had an average continuous capacity of 21.8 tons per hour. After enlarging, the average continuous capacity was increased to 34.9 tons per hour or a gain of 60 per cent.

When heating 23 in. x 25 in. ingots the capacity of original row was 22.30 tons average continuous rate of heating and when rebuilt to the larger size was 25.8, or a gain of 16 per cent.

At another plant, rebuilding a row of four pits each 6 ft. 2 in. by 6 ft. 2 in. and eliminating the division wall between two pits converting them to a row of two pits, each 13 ft. 6 in. x 6 ft. 2 in. was able when heating 21 in. x 40 in. ingots to increase the capacity from 13.68 tons per hour per row to 19.06 tons per hour per row, or a gain of 39.5 per cent.

Another plant rebuilt a row of four pits each 12 ft.

TABLE II

Ingot Sizes and Rolling Rates

Ingot sizes, inches	Average weight per ingot, pounds	Bloom or slab size, inches	Ingots rolled per hour	Net tons of ingots rolled per hour
30x30x68	13,000	8½x10½	20.6	134
		11½x13½	24.2	157
25x25x76	10,000	8½x10½	27.6	138
		11½x13½	31.8	159
26x26x74	10,800	8½x10½	25.3	137
		11½x13½	29.5	159
21x40	13,000	35¾x 4½	28.0	182

Figure 2—Chart showing comparison of blooming mill rolling and heating capacity under varying conditions.

0 in. x 5 ft. 6 in. wide to a row of two pits each 12 ft. 0 in. long by 12 ft. 6 in. wide and when heating slabs increased the heating capacity 33⅓ per cent.

MAXIMUM PIT HOLDING CAPACITY

The maximum pit holding capacity of a given installation should not be confused with the maximum heating rate. The holding capacity is what may be charged into the pit, for purposes of storage under cover, and may or may not be drawn from the pit direct and rolled. For a study of the maximum holding capacity, Figure 1 is submitted to show the effect of pit and ingot size.

In this case two extremes in ingot size, an ingot 21 in. x 47 in. and an ingot 23 in. x 25 in. are used to illustrate the variation in holding capacity.

Row 1 is the original row of four pits, each 6 ft. 3 in. x 7 ft. 4 in. in size. Row 2 was changed from the original construction by removing the division wall between two pits. Row 3 was changed by increasing the length from 7 ft. 4 in. to 13 ft. 0 in. and maintaining the same width as the original row. Row 4 was changed by replacing the original row of four small pits with two large pits each 13 ft. x 14 ft. square.

When charging 21 in. x 47 in. ingots the maximum holding capacity from row 1 to row 4 was increased from 12 to 30 ingots and the tonnage correspondingly from 102.0 to 255.0.

When charging 23 in. x 25 in. ingots the maximum holding capacity under the above conditions was increased from 24 to 50 ingots and the tonnage correspondingly from 106.8 to 222.5.

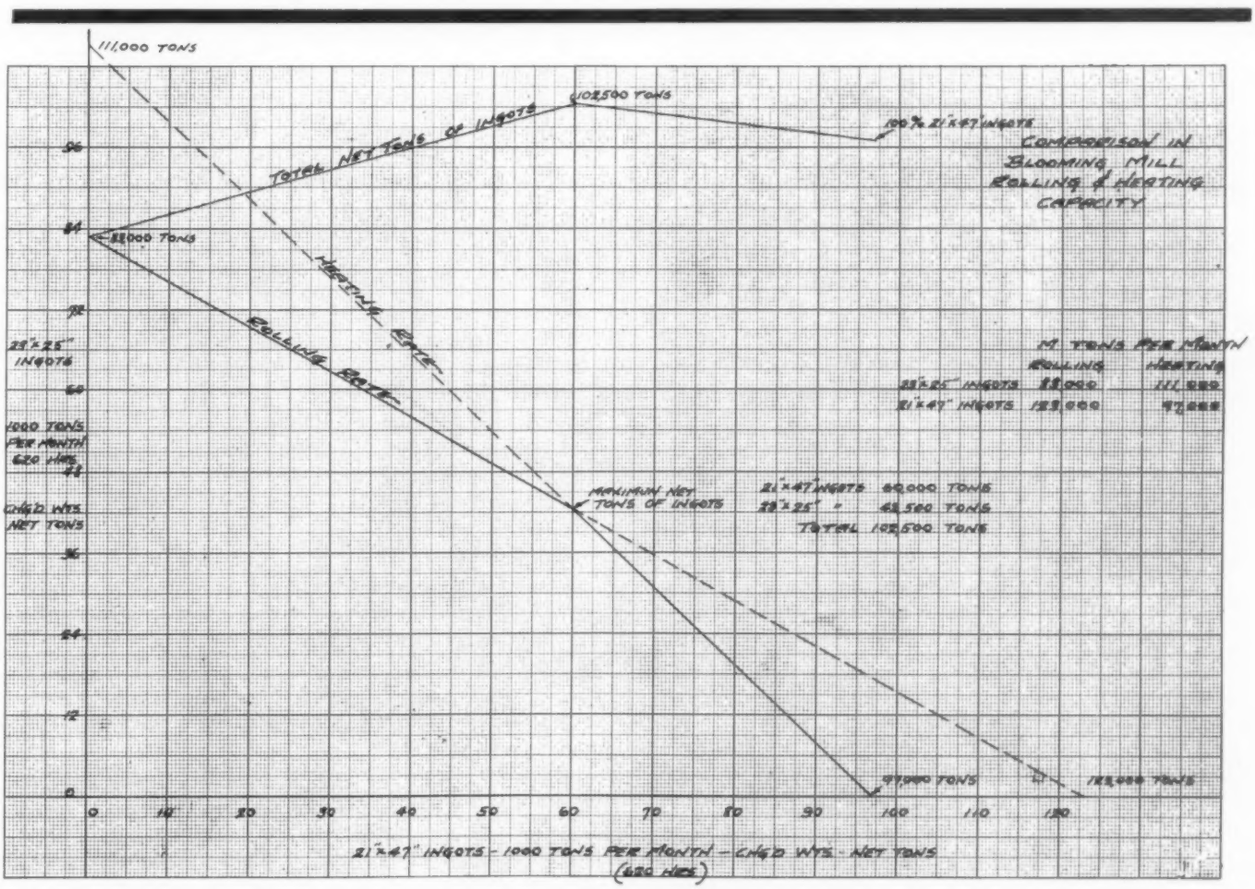
It is interesting to note that in the case of 21 in. x 47 in. ingots each change resulted in a corresponding gain in holding capacity. When charging 23 in. x 25 in. ingots, row 2 held the same as row 1 so that while a gain was made when charging 21 in. x 47 in. ingots in row 2 over row 1 the holding rate was the same when charging 23 in. x 25 in. ingots. However, the per cent of hearth covered in row 2 is 42.2 per cent as compared to 52.8 per cent for row 1 which should improve the heating conditions.

HEATING CAPACITY

The heating capacity of a soaking pit varies with the load, the ingot size, the temperature of the pit and ingots at the time of charging, the kind of fuel, rate of heat input, and design of pit. With few exceptions it is seldom that a pit is filled to the maximum holding capacity, the general practice being to charge at what may be called the normal capacity which is the loading which can be brought to temperature in the time required for the mill; or if loaded to the maximum capacity, to transfer to other pits as soon as the operation permits and complete the heating before rolling.

In Figure 2 is shown a comparison in blooming mill rolling, and heating capacity, in net tons of ingots.

In this plant, rolling 23 in. x 25 in. ingots, the mill


111,000 TONS
102500 TONS
100% 21"x47" INGOTS
COMPARISON IN BLOOMING MILL ROLLING & HEATING CAPACITY
TOTAL NET TONS OF INGOTS
HEATING RATE
ROLLING RATE
M TONS PER MONTH
ROLLING
HEATING
23"x25" INGOTS 88,000 111,000
21"x47" INGOTS 122,000 97,000
MAXIMUM NET TONS OF INGOTS
21"x47" INGOTS 60,000 TONS
23"x25" = 45,500 TONS
TOTAL 105,500 TONS
97,000 TONS
105,000 TONS
23"x25" INGOTS
1000 TONS PER MONTH 620 HRS.
CHG'D WTS. NET TONS
0 10 20 30 40 50 60 70 80 90 100 110 120
21"x47" INGOTS - 1000 TONS PER MONTH - CHG'D WTS - NET TONS (620 HRS.)

has a monthly rolling capacity of 83,000 tons and a heating capacity of 111,000 tons or a surplus of 28,000 tons of heating capacity when rolling blooms.

When rolling 21 in. x 47 in. ingots the mill has a monthly rolling capacity of 123,000 tons and a heating capacity of 97,000 tons or a deficiency of 26,000 tons of heating capacity when rolling slabs.

The maximum production is obtained when rolling a monthly total of 60,000 tons of 21 in. x 47 in. ingots and 42,500 tons of 23 in. x 25 in. ingots or under the above rates a total of 102,500 tons can be heated and rolled. Any variation from the above rates will result in a reduction from the maximum possible capacity due to either limitations due to rolling or heating. This analysis shows how the heating capacity is affected by the rolling capacity for slabs and blooms.

The disadvantage of this limitation in soaking pit heating capacity is that rolling slab ingots in excess of 60,000 tons per month results in a loss in possible blooming mill capacity due to heating limitations. As long as the demands do not exceed 60,000 tons of large ingots per month the heating capacity is ample.

From Table III it may be seen that a change in height of ingot in the case of 14 in. from present standard will increase the capacity of present pits 25.54 per cent. Conversely, a decrease in ingot height reduces the available heating capacity of the pits. As the change in height has only a small effect on the time required to condition, the output is affected in approximately the same ratio as the change in height of ingot.

TABLE III

Effect on Soaking Pit Capacity of Change in Height of Ingot (25½ in. x 25½ in. ingot)

Increase in ingot height, in.	0	6	8	10	12	14
Total weight of ingot, lb.	9,320	10,340	10,680	11,020	11,360	11,700
Increase in weight of ingot, lb.	0	1,020	1,360	1,700	2,040	2,380
Increase in weight of ingot, per cent	0	10.94	14.59	18.24	21.89	25.54

AUTOMATIC CONTROL

The use of automatic control on all new pit installations has proven the value of this equipment for securing a properly regulated operation. By means of combustion and temperature control, the duties of the heaters have been reduced to practically supervision and metallurgical control has been brought to a high degree of accuracy.

Many plants are now equipping their present pits with this control and gaining the value possessed by the new design of pits, due to the use of automatic control.

MODERN SOAKING PIT DESIGNS

The first commercial departure from the conventional regenerator type of soaking pit was that of the recuperative pit, as built by the former Chapmen-Stein Company of Mt. Vernon, Ohio, now a division of the Surface Combustion Corporation, of Toledo, Ohio.

The recuperative type of pit known to the trade as the one-way-fired pit was first built in France by Fours & Apparels Stein of Paris, and was equipped with the Stein refractory recuperator. The pit was patented in the United States, and was brought to this country and adapted to American steel mill practice.

The first unit installed in this country was at the former Donner Steel Company of Buffalo, New York, now a subsidiary of the Republic Steel Corporation, during the year 1926. This unit consisted of one pit and was more or less experimental due to its departure from the French design from the standpoint of capacity, cover mechanism and port construction without deviating from the fundamental principle of design. The pit was 5 ft. 6 in. wide by 9 ft. 0 in. long by 11 ft. 1 in. deep and had a capacity of six 20 in. by 20 in. by 80 in. ingots.

The pit was equipped with a Stein refractory recuperator and coke oven gas was the fuel used.

Based on the results obtained, five pits were built during the year 1928, utilizing the experimental unit as one of the five pits, moved to a new location. The five-pit unit, still in operation, has pits 5 ft. 6 in. wide by 10 ft. 9 in. long by 9 ft. 10 in. deep and a capacity of eight ingots per pit. Each pit was equipped with an individual Stein recuperator made in this country.

Since the installation of the above, 162 pits have been built using the following fuels: coke oven gas, natural gas, blast furnace gas, producer gas, and fuel oil. The size of pits has ranged from the initial size to 6 ft. 5 in. by 20 ft. 8 in. long by 11 ft. 0 in. deep, having a capacity of sixteen 22 in. by 25 in. ingots per pit.

Auxiliary pit equipment followed, with improvement in ingot heating, such as automatic temperature, draft, and combustion control. At the time the first one-way-fired pit was installed, reliable automatic temperature and combustion control equipment was not available, although provisions were made by the installation of orifices in the air and gas supplied to each of the pit ports for a check on combustion efficiency. Automatic draft control was installed during 1928. It was not until the fall of 1934 that automatic temperature control was installed on one pit at the Campbell works of the Youngstown Sheet and Tube Company. Today all installations include these controls.

The installation of the first flat suspended arch for pit covers was made on the experimental pit installed at the Donner plant and the first installation of pit covers, where the drive motors were installed on the pit covers of the soaking pits, was made on a one-way-fired pit installation during the spring of 1930.

Another improvement is the provision for sand sealing the covers. This was a natural outgrowth as covers heretofore were lowered into a depression in the cover rail to seal the pit top.

Another claim for this design is that through the use of the recuperator, installed integral with the pit or in a lean-to, additional space is available in the pit building for installing ingot heating capacity formerly occupied by the regenerator of a reversing pit.

The Morgan Construction Company put their first

Isley design of soaking pit in operation at the Saucon plant of the Bethlehem Steel Company in the fall of 1928 and to date have installed a total of 94 pits in this country, 4 in Canada and 4 in England.

The fundamental principles of this system are: first, the production of draft and air volume by means of push and pull ejectors; second, elevating the temperature of the air for combustion by increasing the effective length of the regenerative system. The general practice is to install an individual draft unit at each end of the system instead of the usual common stack and reversing valve. Each unit consists of a relatively short venturi tube or an ejector equipped with a nozzle connected to the fan. A damper is located in the ejector throat above the mouth of this nozzle. When this damper is open the air passes up the ejector from the suction which draws the gases through the furnace. When the damper is closed the air is deflected back around the nozzle and passes to the furnace.

Since the installation has two ejectors the gases are drawn out of one side of the furnace and air is forced into the other side effecting a push and pull circulation.

The waste gases upon reaching the ejector are mixed with air which reduces the temperature to a point where there is no harmful effect upon the ejector. In this construction stacks, water cooled dampers, valves, and fans are eliminated, common to the regenerative type of furnace.

The Isley system comprises the standard regenerative chamber plus a horizontal flue checker chamber for obtaining relatively large heat storage capacity.

The first pits installed at Saucon were designed to use fuel of 240 Btu. per cu. ft. mixed blast furnace and coke oven gas. Later blast furnace gas of 95 Btu. was tried and found to work successfully.

The Isley soaking pit was among the first to use straight blast furnace gas for fuel in regular soaking pit operation and today has probably the largest number of pits working exclusively on this fuel.

The first Amsler-Morton recuperative soaking pit was put in operation March 17, 1936, at the Carnegie-Illinois Steel Corporation, Mingo Junction, Ohio. Since this initial installation there have been 102 additional pits either installed or under construction.

This makes a total of 103 pits installed in the United States and Canada with an estimated heating capacity of 36,000 net tons per 24 hours. In addition, 4 pits are installed at Chester, England.

The fuels used are natural gas, producer gas, coke oven gas and a mixture of coke oven and blast furnace gas. The pits installed in England using producer gas are equipped with automatic combustion control.

The size of ingots heated covers practically the entire range of ingot sizes used in steel mills and varies from 21 in. in diameter to 30 in. x 52 in.

The pits are equipped with Amsler-Morton recuperators, a special design refractory type to obtain high air preheat and efficiency. Complete automatic combustion and temperature control are standard equipment applied to suit the requirements. Fuel is fired through a port centrally located in the hearth of the pit and waste gases are removed through ports entering the recuperators located on opposite sides of the pit.

Two pits are usually located in a row with a cover crane running the length of the row to remove the covers from any pit desired. The covers are equipped with sand seals to prevent loss of waste gases around the cover.

An excellent detailed description of the design and performance of this pit can be found in the IRON AND STEEL ENGINEER for June 1939, written by E. A. Hawk and M. P. Burns.

The Rust Furnace Company has specialized in rebuilding and modernizing the regenerative type of soaking pits during the last few years, and have installed or rebuilt a total of 32 pits. Fuels used have varied in heating value from a mixture of blast furnace and coke gas as low as 102 Btu. per cu. ft. to straight natural or modified refinery still gas. Pits have been rebuilt to adjust their size to accommodate the change in ingot size and in most cases equipped with complete automatic control, a general description of which is as follows:

With each battery of pits a fan is provided for supplying all necessary combustion air at the pressure required.

Each pit of each battery is arranged for automatic reversal by means of a time clock. A device for manual reversal is also provided. Each pit is operated as an entirely independent furnace and may be fired or dampered down for soaking at will without affecting the operation of any other pit. The temperature within each pit is automatically controlled independent of any other pit. The flow of air to any one pit is automatically proportioned to the flow of fuel completely independent of any other.

Each pit of each battery is provided with a furnace pressure regulator. This regulator actuates the waste gas reversing and regulating dampers, thus regulating the speed of the flow of waste gases, so that the pressure in each individual pit is held constant for all conditions independent of the operation or fluctuation of conditions in any other pit. This apparatus is provided with a gauge so that the operator may have a visual check on the pressure in each pit.

The above described control equipment is so designed and installed that all valves and dampers may be manually operated in case the automatic equipment should fail to function properly. Each pit is equipped with the latest and most improved design of cover, of suspended design, and is arranged to lift vertically from a sand seal provided in the top of the pit before being moved out of position. Controls are provided so that as the cover starts to open the fuel valves and the air and waste gas reversing and regulating dampers are automatically closed for that particular pit.

This company also states that the trend in recent years has been to construct regenerative pits with large size holes. In the past such designs of soaking pit were always constructed with comparatively small holes. This company claims that a regenerative pit provided with the automatic control described above can be charged with 50 per cent or greater of the hearth area covered with steel and still produce an excellent quality of heating. It is also claimed that the fuel consumption in a regenerative pit equipped with the control described will compare favorably with any other design.

In other words, they claim that the control is an important factor in producing quality heating and, at the same time, low fuel consumption.

All of their recent installations of regenerative pits have been thoroughly insulated. This also tends to improve the fuel economy.

For lean fuels the regenerative pit has proven quite successful when provided with a large volume of checkers per pit with extreme depth rather than cross-sectional area. Their experience has proven that for rich fuels such as natural gas and coke oven gas the regenerative pit is also satisfactory. A comparatively small volume of checkers, however, is required. They have designed some installations recently for use with lean fuels with comparatively small regenerators, with a separate heating device for the lean fuel such as a metal recuperator of special design, the air being heated to approximately 1200 to 1400 degrees F. and the lean gas to 500 or 600 degrees F.

The first unit of the circular type pits was installed by the Salem Engineering Company at the Campbell plant of the Youngstown Sheet and Tube Company and placed in operation April, 1935. This unit was 11 ft. 0 in. in diameter with a capacity for heating nine 23 in. x 25 in. ingots or four 21 in. x 47 in. ingots.

This pit was direct fired using premix burners with coke oven gas. As an experimental unit it was installed to test out the application of heat treating principles for ingot heating. The combustion system was comprised of similar type burners and controls used for such class of heating and included a thermocouple through the wall of the furnace connected to a recorder controller for regulating the fuel input and a motor operated valve to regulate the gas pressure to the burners to control the combustion and maintain the desired furnace atmosphere. The pit was also equipped with a lifting type of cover and sand seal, and a pit crane designed to move the cover in either direction.

Draft was regulated by means of a stub type stack discharging the waste gases at an elevation slightly higher than the top of the pit.

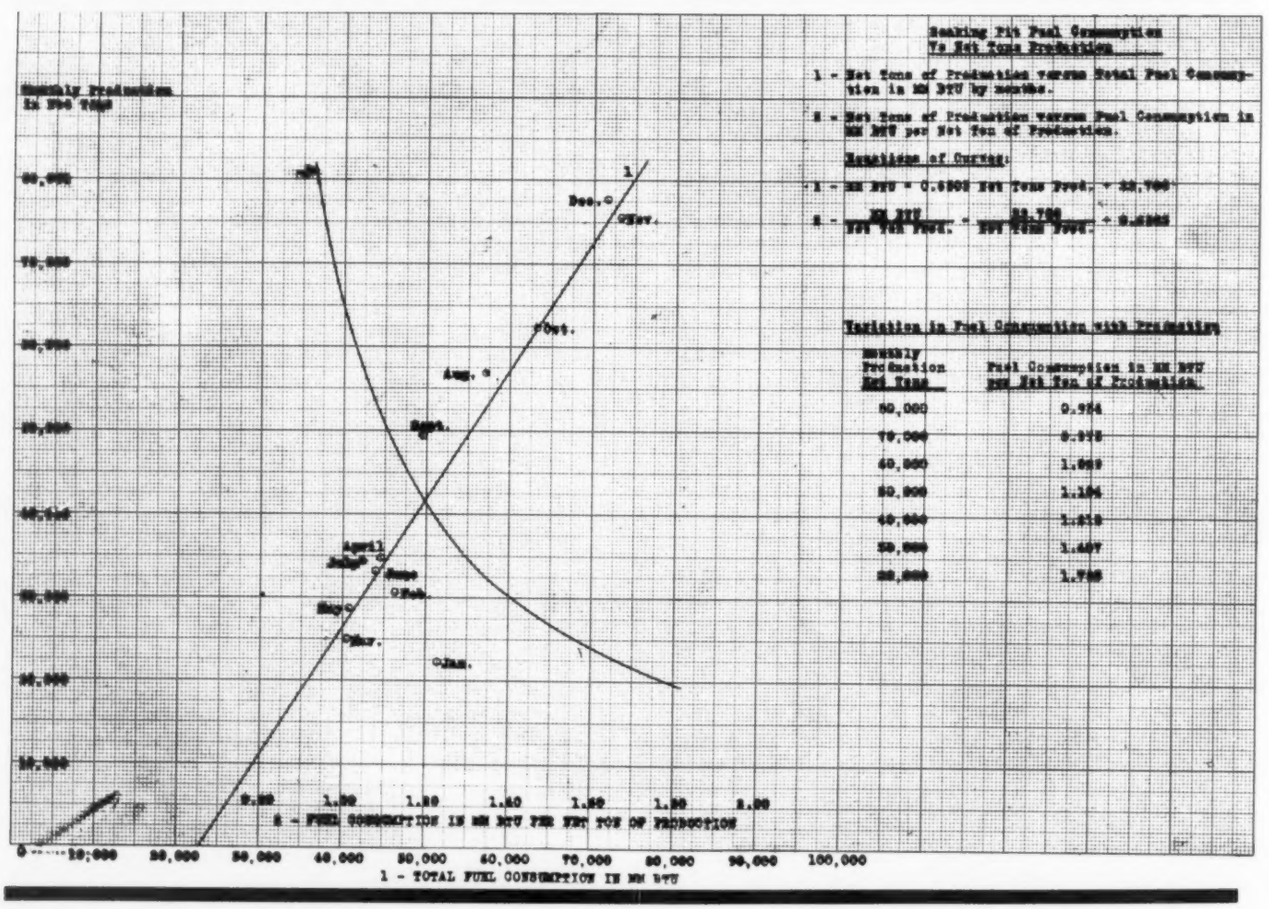
Since the installation of the above, 25 pits have been installed in the United States and 36 in Europe, using the following fuels: coke oven gas, natural gas, a mixture of 300 Btu. per cu. ft. of coke oven and blast furnace gas, producer gas, and fuel oil. The size of the pits ranges from 11 ft. 0 in. to 20 ft. 0 in. in diameter.

SUMMARY

In reviewing the present status of soaking pit installations and the various types that are now available, we find that the designers have all worked toward simplification in construction from the original regenerative pit.

There are a number of features that have been

Figure 3—Chart showing soaking pit fuel consumption with varying production.


Soaking Pit Fuel Consumption
Vs Net Tons Production
1 - Net Tons of Production versus Total Fuel Consumption in MM BTU by months.
2 - Net Tons of Production versus Fuel Consumption in MM BTU per Net Ton of Production.
Equations of Curves:
Variation in Fuel Consumption with Production
Monthly Production Net Tons
Fuel Consumption in MM BTU per Net Ton of Production.
Dec.
Nov.
Oct.
Aug.
Sept.
April
July
June
Feb.
May
Mar.
Jan.
2 - FUEL CONSUMPTION IN MM BTU PER NET TON OF PRODUCTION
1 - TOTAL FUEL CONSUMPTION IN MM BTU

standardized and common to all the latter type pits, such as a sand seal with lifting type of cover, and automatic control of furnace temperature and pressure and combustion. Water cooling of parts has either been eliminated or reduced to a minimum. Insulation is also standard for all designs.

It is in the application of fuel that we find the greatest variation and all types have utilized systems that their designers decided were most applicable for the purpose.

In both the reversing and the non-reversing type of pits, the designers have applied a wide variation in principles of combustion and heat transfer. As the methods of applying fuel to the regenerative pits have already been described, the following remarks are applied to the non-reversing type of pits:

The Chapman-Stein pit is fired through a burner located in one end of the pit close to the top, in the long direction over the ingots, the waste gases passing downward and out a port located close to the bottom on the same end of the pit the burner is located. From here they pass through a recuperator to the stack. Space is provided over the tops of the ingots for combustion before the gases pass downward and through the outlet port. The type of burner used is in principle usually of the long flame type.

The Amsler-Morton pit is fired from a single dry pipe burner through an alloy burner insert approximately 2¾ in. in diameter, through a circular bottom port approximately 3 ft. 0 in. in diameter located in the center of the bottom, the top of the port extending about 19 in. above the pit refractory bottom or approximately 5 in. above the coke bed. The waste gases are removed through outlets near the four corners, just above the coke bed, and pass on to four separate recuperators set symmetrically in relation to the pit.

The Salem pit has so far been installed without recuperation. This pit is circular in form with all firing done through the side walls near the bottom of the furnace. The fuel is introduced into the furnace through a number of burners each of relatively small capacity. The burners are placed tangentially so that the burning gases leaving them and mixing with the products of combustion in the furnace impart a forced circular whirling motion to all the gases. The burners used are either of the premix or nozzle mixing type to secure complete combustion before the products of combustion come into contact with the ingots. The products of combustion pass through the ingots from the burners to an outlet flue located in the center of the furnace at hearth level.

The main difficulty in evaluating the performance of the various types of pits has been to secure conditions of operation that are comparable. The most conclusive comparisons have been in those plants in which the various designs are installed and operate under similar conditions.

In few other heating operations are the variations in demands as great as that from soaking pits. In recent years metallurgical requirements have become most exacting and the prime requisite is to produce an ingot properly heated to meet these demands.

Other equally important factors are the kind of fuel and, where more than one fuel is to be used, the frequency that changes may be required from one fuel to another. The pit design must be such that this change will not affect either the capacity or the quality of heating. When this has been accomplished then the pit that produces a prime product at the minimum cost is the most economical. For a complete analysis, total cost should include operation, maintenance, conditioning and fixed charges.

The cost of fuel per ton of ingots heated is an item most frequently quoted. This will vary with the temperature of the ingots charged, per cent of loading, metallurgical heating limits, rate of heating and delays. In general, the cost will decrease with increase in production for any plant due to the percentage of increase in operating time over delay time.

To show how this will vary, Figure 3 gives the soaking pit total monthly fuel consumption (which includes an unaccounted-for charge) compared to the net tons per month production, for one plant.

This chart was made by plotting the total monthly fuel and monthly production for the year 1938. The year selected was one in which the production varied from approximately 22,000 tons minimum to 78,000 tons maximum. At 78,000 tons production the fuel consumption is almost one-half that at 22,000 tons. This represents regular operation with the normal ratio in class of product from slabs to blooms. The unaccounted-for charge amounts to 8.0 per cent of the metered fuel.

A careful analysis of the present designs of soaking pits for any particular demands will disclose constructions available capable of meeting these requirements and the numerous installations provide an opportunity for those interested to select the one most applicable.

DISCUSSION

PRESENTED BY

P. M. OFFILL, *Vice President*, Amsler-Morton Company, Pittsburgh, Pennsylvania

F. E. LEAHY, *Fuel Engineer*, Youngstown Sheet and Tube Company, Youngstown, Ohio

M. J. CONWAY, *Special Engineer*, Petroleum Industry Development, Lukens Steel Company, Coatesville, Pennsylvania

G. R. McDERMOTT, *Vice President*, Surface Combustion Corporation, Toledo, Ohio

C. H. WILLIAMS, *Assistant Chief Engineer*, Pittsburgh District, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania

H. N. HOLSTEIN, *Superintendent*, Blooming, Bar and Jobbing Mills, American Rolling Mill Company, Ashland, Kentucky

FRANK ROBERSON, *Superintendent of Construction*, Carnegie-Illinois Steel Corporation, Gary, Indiana

P. M. OFFILL: Mr. Leahy has presented an interesting paper on a rather difficult subject. There has been comparatively little information gathered regarding the treatment accorded steel in a soaking pit other than to get it hot enough to roll fairly well. To properly heat the many grades of steel manufactured today, it is necessary to have a precision heating machine.

We have made efforts to gather detailed information

regarding the effects of a greatly improved quality of heating without a great deal of success, and it has therefore been difficult to reduce it to dollars and cents. We often hear the opinion voiced that modern pits are doing an excellent job, much better than it was possible previously, but without detailed figures to substantiate it.

Only recently have soaking pits been asked to amortize themselves, and it is true that the modern soaking pit reduces fuel, maintenance, and labor, but economies resulting from proper heating far outstrip all other factors.

A paper could well be presented by some of our eminent metallurgical and blooming mill men on the subject "Effects Produced by the Proper Heating of Steel."

To amplify Mr. Leahy's reference to fuels as used with our pits, we wish to say that a steel company at Hamilton, Ontario, has used blast furnace gas at atmospheric temperature and blast furnace gas preheated to 550 degrees F. in combination with air preheated to 1850–1950 degrees F., as well as mixed coke oven gas and blast furnace gas of 135 Btu. per cu. ft., and straight coke oven gas.

F. E. LEAHY: I think Mr. Offill has a real good thought with his suggestion for a paper by some of our metallurgical and blooming mill men on the subject "Effect Produced by the Proper Heating of Steel." In most of the steel plants today metallurgical observers are used in the blooming mills to record the heating and rolling practice, and I believe a compilation of their findings combined with the results obtained in the finished product would be of value to the industry.

His reference to the fuels used in the soaking pits at a steel company at Hamilton, Ontario, is very interesting. Such a wide range of fuels calls for very excellent control in order to secure uniform satisfactory results.

M. J. CONWAY: I was glad to hear Mr. Leahy bring out one point, and that is the difference in weight that various heights of the ingots bring about. In comparing heating fuel rates, we usually think of 20 in. x 22 in. or some other conventional size ingots without considering the height. It is very easy to have the wrong impression of the weight heated without considering this dimension.

G. R. MCDERMOTT: I would like to ask Mr. Leahy, as an operator, to what extent is automatic temperature control, *i.e.*, controlled program (time-temperature), justifiable?

With a program control of heating ingots, the intial temperature of the ingots as charged, of course, has a considerable bearing on the proposed controlled program of heating. Where there is considerable variation of the initial temperature of the ingots as charged, I question the justification of a program control due to complications of setting the rates.

F. E. LEAHY: Mr. McDermott brings out a very interesting suggestion that has been discussed on numerous occasions in connection with the control of soaking pits, and that is the use of automatic program control of time and temperature. In recent years we have seen the introduction of ingot heating furnaces with all the features of accuracy common to heat treating furnaces. For the heating of ingots this has brought to the attention of many operators the desirability of utilizing the same accuracy of control inherent in modern heat treating furnaces. They are now available to those operators who care to carry their accuracy of heating to this degree.

In the heating of ingots of a grade generally known as "delicate," or in some grades of alloy steels, there is no doubt that such a type of ingot heating furnace is quite essential to securing the metallurgical requirements through accurate control of heat input and furnace atmosphere.

In the heating of the ordinary or common grades of ingots it has not been considered necessary for accurate control of time and temperature other than not to exceed a predetermined maximum rate of heat input.

C. H. WILLIAMS: Mr. Leahy hit on a very vital point in discussing the effect of the size of pit and size of the ingot on the total coverage and the overall output of heated steel. Increasing coverage by installing large holes in limited space appears to compromise the flexibility of operation and the overall tonnage through charging and drawing delays. There are reports that on large soaking pits the practice of partial recharging before complete drawing has been successfully worked out. Has anyone present had experience with such a practice? Is it practical to start recharging a large soaking pit before you have completely drawn it?

F. E. LEAHY: In commenting on the remarks of Mr. Williams on the effect of pit size and flexibility of operation, this paper discusses one case in which a pit can be too large particularly where the operations are intermittent and rolling is confined to 8-hour periods.

The writer has seen 29 ingots drawn consecutively in 57 minutes and the last ingot had the original scale plus that built up during the heating period intact. Also, all of them rolled satisfactorily which would indicate that under proper conditions a large pit may be used quite successfully.

Mr. Williams also asks the question, "Is it practical to start recharging a large soaking pit before you have completely drawn it?" It is generally agreed by all operators that the best results are obtained when the ingots are drawn consecutively from a pit and as quickly as possible. I do not know of any practice of recharging a soaking pit before it is drawn other than where a delay occurs and steel is charged with the pit partially empty. An objection to this practice is the effect of frequent operation of the cover causing a general lowering of the pit temperature, and often accompanied with a change in furnace atmosphere with a tendency to loosen and drop off the scale on the ingots, in the pit, if done too frequently.

H. W. HOLSTEIN: It would seem to me that the troubles which they refer to would be eliminated if we could charge all steel hot. We have had some experience along the line referred to by Mr. Williams and it is our opinion that you do not do a good job when trying to charge and draw a pit at the same time. I feel that large pits can be too large for good heating and also may present a uniform heating problem as well as affect capacity on account of flexibility.

When pits are made larger by removing division

walls it is our experience you must exercise care in handling your product or you produce a non uniform scale condition which entails extra work to correct. Has that been your experience?

F. E. LEAHY: Referring to the remarks of Mr. Holstein on the question of pit size, I do not agree that large pits can not produce good and uniform heating and provide the flexibility necessary in most plants.

The introduction of accurate controls has made practices possible in the large pits that were not practical in the smaller pits, such as leaning the ingots against each other. This makes it possible to charge them so as to get uniform heating around the surface of the ingot which was not always the results secured when leaned against the side walls. This also makes it possible to produce a uniform scale condition referred to in his remarks.

The removing of division walls is usually but a step in arriving at the proper dimensions for the best distribution of heat and ingot capacity throughout the soaking pit. To get the best results it is often desirable when a change such as the removing of the division wall is made to change the method of firing the pit so that the proper distribution of the gases through the pit is secured.

FRANK ROBERSON: I would like to ask the author to give a short discussion on the advisability of using recuperators on modern pits.

F. E. LEAHY: In answer to Mr. Roberson's request for a short discussion on the advisability of using recuperation on modern pits, I believe the following covers the question:

The basic reason for recuperation is to recover the waste heat from flue gases to the most economical point and return them through preheated air for combustion.

Where fuel economy is one of the prime purposes and can be secured with the desired heating, it is in general desirable to install recuperators.

Where the proper fuels are available to supply the heat without recuperation and the most accurate control necessary to secure the quality of heating as that secured in the finest of heat treating furnaces then recuperation is not desirable.

Also, where there is produced an excess of surplus fuel over normal requirements such as coke oven gas which is capable of supplying the heat necessary in the time required, investments in heat recovery apparatus can not be justified.

Another case is where intermittent operation is the normal practice and fuel costs are relatively low; the extra investment for heat recovery is sometimes not justified.

From the above it can be seen that the merits of recuperation must be analyzed for the particular application in order to make certain that the extra investment for the apparatus will be ample to justify the investment.

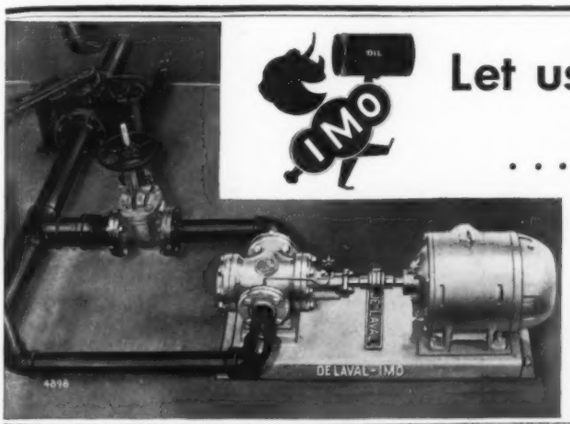
SHALLOCK DISCUSSION

(*Continued from page 63*)

E. W. SHALLOCK: In the batch process it is difficult to get a uniform moisture and porosity in the charge. Because the porosity and moisture will vary greatly in a batch there will be irregular ignition, and consequently the bed will not sinter down uniformly. If all conditions are right, you can get as good sintering with one process as with the other.

JOHN HEALD: What would be the characteristics of good sinter and what percentage of fine returns would be considered good operation?

E. W. SHALLOCK: That varies considerably. It depends on the material you are sintering. If you take an ore that has a considerable amount of granular pieces—large granular pieces in it—you will need very little return material; whereas, when you have extremely fine flue dust, then you have got to make a lot of returns and bring them back and open up that bed because you can't sinter it otherwise at all. So, it might be 40 per cent, in the latter case, and 10 per cent in the former case.



Let us show you an IMO at work

. . . The De Laval - IMO Oil Pump

runs quietly, without vibration or pulsation, at standard motor, or even turbine, speeds. There are no gears, valves or reciprocating or unbalanced parts and the oil is delivered smoothly, as from a piston moving always in one direction. IMO pumps handle all grades of oil against all pressures. The photograph shows an IMO pump supplying fuel oil to burners in a steel mill. Ask for Catalog I-67.

IMO PUMP DIVISION

of the De Laval Steam Turbine Company, Trenton, N. J.

98% Reduction in Shutdowns due to fuses has resulted since we installed BUSS Super-Lag FUSES

"We keep a record of all shutdowns"

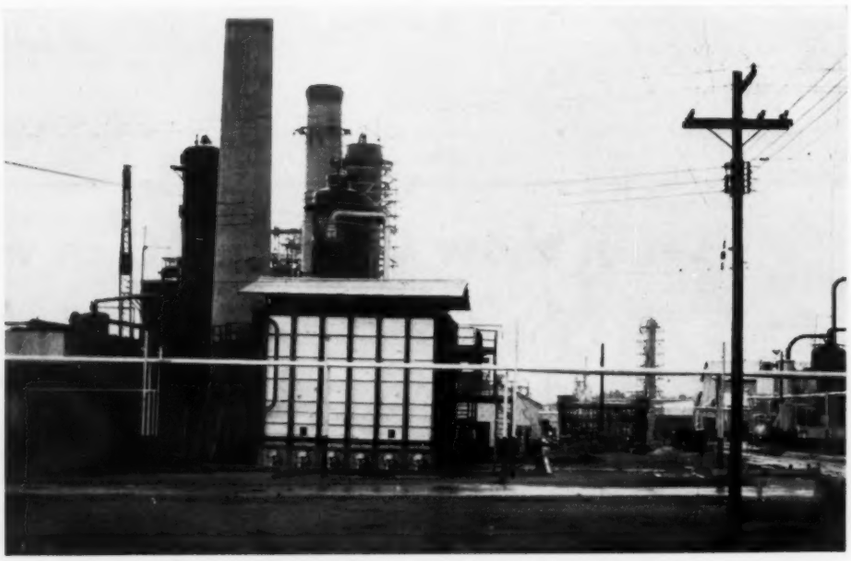
. . . says Chief Electrician Howard I. Evans, Lion Oil Refining Co., Eldorado, Ark.

. . . "and," continues Mr. Evans,

"WE NOW OPERATE WITHOUT A NIGHT MAINTENANCE MAN"

"We have approximately a 2000 h. p. load consisting of about 130 motors ranging in size from 1 to 250 h. p. Most of these motors are protected by fuses.

"In order to locate sources of trouble we keep a



"We now operate without a night maintenance man"

record of all shutdowns. Several years ago we were surprised to find shutdowns were often due to poorly designed fuses blowing needlessly.

"To try to correct this condition we installed BUSS Renewable Fuses. The results were better than we had hoped for—shutdowns due to fuses dropped to about 1% of their former number—a reduction of over 98%.

"We have so little fuse trouble that we now operate without a night maintenance man—and in the past year I've been routed out of bed only about three times.

"I'll hand it to BUSS fuses, they helped us."

Anyone Interested in Plant Operation or Maintenance Can Profit by Following Mr. Evans' Lead

The experience of Mr. Evans is remarkable only in that he kept such accurate records. Thousands of other executives have, over the past many years, found that BUSS Super-Lag fuses have greatly reduced the number of useless shutdowns that formerly occurred in their plants.

There are sound reasons why BUSS Super-Lag fuses don't blow needlessly.

Fuse-Case Design Helps Prevent Shutdowns

A Renewable fuse is a contact making device—not just a container for a link. Poor contact must be prevented, otherwise excess heating will soon raise the temperature of the link and cause it to blow needlessly. Then the circuit is out and the user is penalized by a useless shutdown.

The chance of poor contact causing a BUSS fuse to open needlessly is reduced to a minimum by a patent Fuse-Case design that has resulted from years of laboratory and field tests.

When a BUSS fuse is assembled, good contact is automatically made on the link—and this good contact will remain no matter how long the fuse is in use.

Time-Lag Helps Prevent Shutdowns

Starting currents or other harmless overloads often cause ordinary fuses to open.

To guard against such blows—"lag-plates" are attached to the BUSS Super-Lag link. They give the fuse a long time-lag or retarded blowing point.

Thus, when two or more motors start at the same time or a motor starts under a heavy load or a machine jams momentarily or other such things occur that cause harmless overloads, the BUSS fuse holds instead of blowing—and the circuit is kept in operation.

How to Get Quick Results in Your Plant

If you believe that a protective device should guard against senseless interruptions of electrical service as well as against electrical hazards—just pass the word along that all stock and purchase records should be changed immediately to call for BUSS Super-Lag fuses.

If you would like more information about BUSS Super-Lag fuses to pass along to other men in your plant, ask for bulletin Rcs. It shows why BUSS Super-Lag fuses help prevent work stoppages as well as guard electrical equipment. Bussmann Mfg. Co., St. Louis, Mo., Division McGraw Electric Company.

"I'll hand it to Buss Fuses, they helped us"

BUSS SUPER LAG FUSES
WHY BUSS FUSES DON'T BLOW NEEDLESSLY
10 FEATURES in the design of the FUSE-CASE help make it possible
The SUPER-LAG development in the FUSE-LINK completes the job.

WANT TO PREVENT "ALL-OUT" CIRCUITS?

"All-Out" is a mighty good defense phrase, but it's a terrible headache when it applies to wiring circuits. And right now the continuous use of production circuits is setting the stage for scenes like this in hundreds of plants. When the load builds up *and stays up*, copper heating dries out ordinary insulation and vibration opens up cracks that are bound to make trouble . . . unless the danger is averted *in advance* through the use of Rockbestos permanently insulated wire and cable.

Another thing to remember is that expanding production is likely to require new feeders and branches to new plant areas, some of them of necessity too close to steam-lines, drying ovens, boilers, furnaces, etc. If this happens in your plant remember previous wire failures and insist upon installing a wire that won't interfere with production by failing in the pinches. And, remember, too, that Rockbestos wires give you fire protection because they won't burn or carry flame.

For almost a quarter of a century Rockbestos has made nothing but wires, cables and cords for severe service. During that time a lot of "know how" has been acquired in turning out *permanently insulated* wire that is resistant to heat and moisture, alkalies, caustics, fire, oil and grease. Hundreds of constructions have been developed to meet unusual requirements. This experience is yours for the asking. Just tell us what is bothering you and your wire and we'll try to lick it. Rockbestos Products Corp. 809 Nicoll St., New Haven, Conn.

Also refer to McGraw-Hill Electrical Buyers Reference

Rockbestos A.V.C. Boiler Room and Lighting Wire
(Underwriters and Nat. Elec. Code — Type AVA
maximum operating temperature 110°C. (230°F.)

Rockbestos A.V.C. Power Cable
(Underwriters' and Nat. Elec. Code — Type AVA
maximum operating temperature 110°C. (230°F.)

Rockbestos All-Asbestos Power and Rheostat Cable
(Underwriters' and Nat. Elec. Code — Type AI
maximum operating temperature 125°C. (257°F.)

ANTICIPATE YOUR REQUIREMENTS!

New York · Buffalo · Cleveland · Detroit · Chicago · Pittsburgh · St. Louis · Los Angeles · San Francisco · Seattle · Portland, Ore.

Rockbestos A.V.C. Motor Lead and Apparatus Cable — Underwriters' and National Electrical Code Type AVA—one of 118 different permanently insulated wires.

TIN PLATE PLANT AT FULL OPERATION

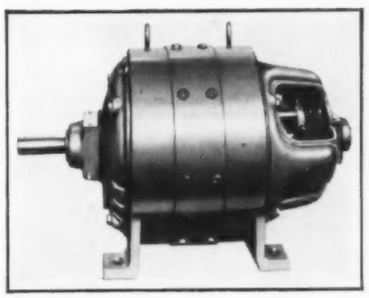
▲ Capacity production at the Shenango Tin Plate Plant of Carnegie-Illinois Steel Corporation, New Castle, is now operating with 10 additional hot mills. With resumption of the additional units, all 40 hot mills of the Shenango Plant will be in operation for the first time since late 1939.

Idle for a year and a half, 20 mills at Shenango were returned to production June 16, this year, to meet increased demand for hot rolled tin plate resulting from the national defense program. Ten more units were placed in operation July 14. The final group of 10 mills put into operation August 18 will provide employment for approximately 500 men. The plant's total employment will be approximately 3500, many of whom are recalled former employees.

EXCITER GIVES CLOSE ELECTRICAL CONTROL

▲ Efficient quick-response regulation for automatically holding constant output on d-c. and a-c. machines is available with the new Regulex exciter developed by the Allis-Chalmers Manufacturing Company. This rotating regulator reduces the first cost of a generator or motor installation because exciter and regulator are combined in one unit. The Regulex consists of a differential amplifier for controlling the excitation on d-c. motors and generators to give constant voltage, current, speed or tension.

The Regulex was originally developed for steel mill use, principally for giving constant tension on winding and unwinding coils. It is now being applied to other steel mill drives and mine hoists.



Regulex exciters are being developed for all sizes of d-c. machines, and they are applicable to a-c. synchronous motors, generators and condensers. They will also be applicable to constant tension drives in paper mills.

JESSOP TO INSTALL 84 IN. PLATE MILL

▲ The Jessop Steel Company, Washington, Pennsylvania, has begun construction of a new 84 in. two-stand plate mill, according to an announcement by Harry Wilson, Jr., Works Manager. This is part of a large plant expansion and modernization program being undertaken by Jessop in the interests of National Defense, since the tool steels, stainless steels, and special alloy steels they manufacture are vital to armament production.

The new plate mill will be housed in an extension of the company's sheet mill building, the extension consisting of four additional bays. The mill is electrically driven and will be supplemented by the installation of six modern heat treating furnaces capable of increasing plate production 50 per cent.

EFFICIENT PROGRESS FOR SHELL MAKING

▲ When the Assel cross roll and elongator mill for processing mechanical tubing was designed and constructed eight years ago by the Timken Roller Bearing Company, no thought was given that it would some day rapidly produce shell forgings for the United States and Great Britain.

Yet today the Witter shell forging process of Salem Engineering Company, which utilizes the Assel mill, is being used by two large companies in the Pittsburgh district to produce large quantities of shell forgings.

Two mills are in process of construction and contracts for numerous others are pending.

The first Assel mill was designed and built at Canton, Ohio, during 1933 and 1934 and was used in conjunction with piercing mill and regular tube mill equipment operating at the Wooster plant of the Timken Steel and Tube Division. On March 3, 1935, the first complete Assel mill started production of 2½ in. outside diameter x ¼ in. wall thickness mechanical tubing. Hence, the original mill which utilizes three humped rolls in the manufacture of tubing is not very old and the Witter process, an adaptation of this method for roll-

ing closed end tubular products, is a comparative youngster already showing signs of unusual strength according to production figures.

Consequently a proven unit was utilized and with the addition of mandrel handling and sizing equipment, the processing of closed end projectiles, such as shell forgings, was realized.

Shell forgings were being produced on experimental mills during 1940 and the first Witter process mill began producing shells at a Pittsburgh district plant on January 10, 1941. This company is operating three Witter process units and a larger unit is being installed at the present time. The existing mills are producing shell forgings ranging from 75 mm. to 5 in. anti-aircraft, while the larger unit will produce forgings ranging from 105 mm. to 7 in.

Another Witter process unit is making 75 mm. shell forgings at a plant in the Pittsburgh district.

Although the Salem Engineering Company originally set up an estimated unit production of 280 75 mm. shell forgings per hr., numerous hourly runs of over 300 and some 8 hr. turn productions of approximately 2000, and 24 hr. day productions of 5600 have been realized.

Short runs on 75's have been as high as 7 per min. and productive averages deducting lost time have been about 275 per hr.

On 105 mm. shells maximum hourly production has been approximately 287 pieces with 8 hr. turn production of 1600.

As a result of recent production speed-ups, Salem engineers believe that with the proper type of blank producing equipment, a maximum of 360 75 mm. shell forgings should be produced in an hour, while even the larger 155's could be turned out at a rate of 160 per hr.

The Witter process has been designed to meet mass production requirements and employs the use of either round or round cornered square billets; modern heating equipment; a high production blank piercing press; and rolling to rough turned diameters.

Although Salem contemplated the use of an entirely new mill from beginning to end, the company found that the process was ideally adaptable to equipment already existing in many plants. Not only could a group of single punch and single die presses be used to form the pierced blank, but it was found that board or steam drop hammers and conventional upsetters could also perform the same function. Because the finishing mill used in the process is capable of handling not less than 250 75, 90, or 105 mm. shells per hr. and because this type of equipment is expected to be used at its highest production possibilities, Salem believes that a group of presses or a pair of hammers or upsetters should be utilized.

Where ordinarily from 60 to 75 blanks are produced from a conventional press, it would require from three to four such units to provide the 250 per hr. necessary for the Witter process. To reach the higher production, and Salem is estimating

TRADE AUTOMATIC MARK

MANUFACTURERS FOR OVER THIRTY YEARS

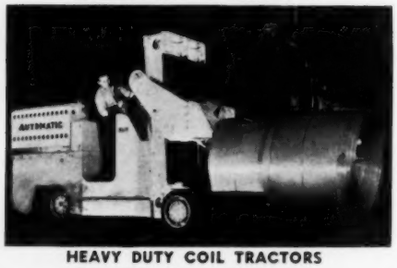
MODERN *Electric Propelled* INDUSTRIAL TRUCKS

FOR ECONOMICAL MATERIALS HANDLING

- COIL AND FORK TRACTORS
- SHEET AND TIN PLATE HANDLERS
- BOSH TRUCKS
- LOW AND HIGH LIFT TRUCKS
- LOAD CARRIERS
- TRACTORS — CRANES

COIL TRACTORS
Capacities 8,000 to 18,000 Lbs.

BOSH TRUCKS—*Tiering Type*



HEAVY DUTY COIL TRACTORS
Capacities Up to 30,000 Lbs.

FORK TRUCKS
Telescopic and Non-Telescopic Lifts
For Sheet Coils and Pallet Handling
Capacities 3,000 to 7,000 Lbs.

REQUEST DETAILS AND LITERATURE

SHEET AND TIN PLATE HANDLERS
Capacities 8,000 to 18,000 Lbs.—Non-Telescopic and Telescopic Lifts

Listed Under Reexamination Service of UNDERWRITERS' LABORATORIES

AUTOMATIC TRANSPORTATION CO.
47 W. 87th St. Div. of the Yale & Towne Mfg. Co. CHICAGO, ILL.

that with proper equipment 360 75 mm. shells per hr. could be produced, more presses of course would be necessary.

From actual experience it was found that in order to maintain production of 250 shell forgings per hr. on the finishing mill, two drop hammers can provide sufficient blanks and similarly two upsetters could meet that production requirement.

Where no existing equipment is available, Salem has designed and are building a double turret type high production blank piercing press capable of supplying from this single unit the entire requirements of the finishing mill.

Using the complete process as developed by Salem Engineering Company, an estimated cost of $39.50 per 1000 shell forgings produced on the basis of 250 per hr. has been made. This covers labor and maintenance, but overhead and amortization costs must be added, as well as other factors, in case existing equipment is utilized in place of the high speed piercing press mentioned above.

A brief description of the operation of the Witter process follows: Billet steel is properly upset, forged, or pressed to form the pierced blank. This blank is conveyed to a loading station of the finishing mill where it enters the break down pass of the humped rolls with a smoothly machined mandrel inserted in the cavity of the pierced blank. The mandrel is kept bottomed in the blank by pressure from a pushing cylinder during the breakdown, elongating and cross rolling operation. On elongating, the metal wraps tightly on the mandrel as it passes through the humped rolls, thus producing a smooth and uniform cavity in the shell forgings. After leaving the rolls the forging is sized with mandrel inserted and then the mandrel is automatically stripped, leaving the shell forging completed and ready for final machining operations elsewhere. Ten or more mandrels are rotated in the automatic cycle and are properly cooled, thus assuring a uniform production of shell forgings.

Salem Engineering Company claims an outstanding feature of the Witter process is to be found in substantial savings of material by producing a 75 mm. shell forging from approximately 16 lb. of billet steel as against 20 lb. utilized by some processes. The machined forging weighs approximately 10 lb. Hence on large scale mass production, it is said that a weight saving amounting to 25 per cent would be a decided national defense factor in view of the tight steel situation. This saving in material is also reflected in transportation to the forging plant, machining and tool costs, and power requirements.

Production Capacity
Witter Shell Process

	Original estimate	*Latest estimate based on actual production*
Mill No. 1:		
75 mm.	280 per hr.	360 per hr.
90 mm.	240 per hr.	300 per hr.
105 mm.	200 per hr.	240 per hr
Mill No. 2:		
105 mm.	200 per hr.	240 per hr.
5 in. AA.	180 per hr.	200 per hr.
5.5 in.	160 per hr.	180 per hr.
155 mm.	160 per hr.	160 per hr.

ON GUARD
against guesswork
GUARDING against production failures is a necessity at any time but particularly so when production schedules are being pushed at top speed. Hays indicating and recording instruments for steel mills accurately indicate combustion conditions in soaking pits, open hearths, annealing furnaces and slab mills—gas pressure indicators, air flow indicators, draft and pressure gages, both indicating and recording, give a constant picture of what's going on inside and guard against harmful, inefficient and costly errors.
HAYS "OT" DRAFT RECORDERS SHOW TWO DRAFT VALUES, TWO PRESSURE VALUES, TWO DIFFERENTIAL VALUES OR A COMBINATION OF ANY TWO OF THESE. FOR SOAKING PITS, OPEN HEARTH, ANNEALING FURNACES, SLAB MILLS. ASK FOR PUB. 39-252.
The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

ADVERTISING PAGES REMOVED

INLAND ADDS FURNACE

▲ Inland Steel Company has announced that it has entered into a contract with the Arthur G. McKee Company, of Cleveland, for the construction of a blast furnace at its Indiana Harbor (Indiana) Works. The furnace will be the company's sixth blast furnace, and will have a daily capacity of 1000 tons of pig iron.

NEW J. & L. PROPERTY

▲ To increase its pig iron and steel output, largely in the interest of the National Defense emergency, the Jones & Laughlin Steel Corporation's president has leased a large tract of land containing deposits of iron ore in St. Lawrence County, New York. The property is to be developed as an iron ore mine to supplement present J & L ore operations and properties in Minnesota and Michigan.

The tract of 3200 acres, situated 65 miles east of Watertown, New York, on the western slope of the Adirondack Mountains, is being leased from the Benson Iron Company, Inc.

NEW LATHES FOR DEFENSE PROJECTS

▲ A series of 16 huge lathes for machining big guns and other defense items for the United States Navy are now being assembled in the Pittsburgh plant of the Mackintosh-Hemphill Company. The lathes are of the "heavy duty engine" type and are among the largest ever constructed.

As soon as the lathes are rushed to completion, they will be specially prepared for shipment to various Naval Ordnance plants and steel mills throughout the country.

HANNA CORPORATION USES FOURTH FURNACE

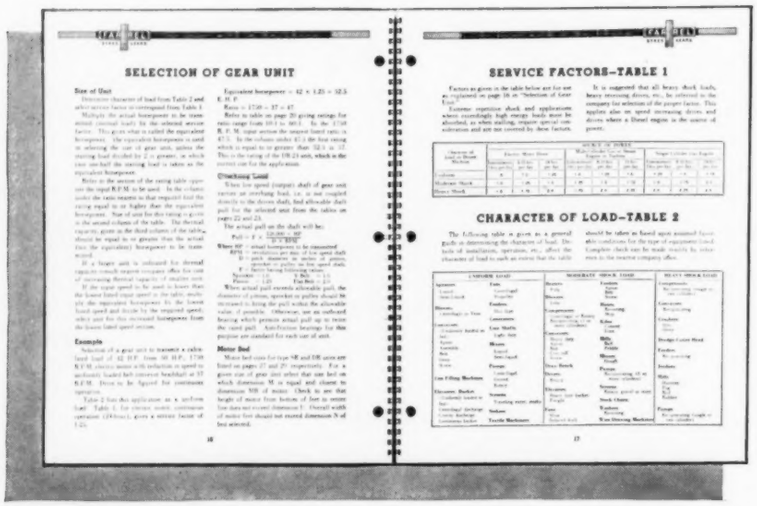
▲ The four-furnace plant of The Hanna Furnace Corporation, pig iron producing Buffalo subsidiary of National Steel Corporation, began 100 per cent operations recently when the plant's No. 1 blast furnace was lighted for the first time in more than 12 years.

The No. 1 furnace is The Hanna Furnace Corporation's oldest installation of equipment. It was allowed to stand idle during the depression because its production was not required to meet the existing demands for iron and steel products. The company had considered dismantling the furnace. When the defense program developed a critical need for pig iron, however, it was decided to rebuild and modernize both the furnace and auxiliary equipment.

Reconstruction work was started late last year and was completed within six months, or in about one-half the time normally required for the rebuilding of a blast furnace. At the same time, The Hanna Furnace Corporation acquired a 3000 hp. boiler plant from an abandoned works of another steel company. Five boilers were dismantled, transported, reconditioned and installed in a new boiler house and this job also was accomplished in record time.

As a result of this program, two huge installations of equipment have

(*Please turn to page 83.*)



THESE SERVICE FACTOR TABLES

Aid in Quick Selection of Farrel Gear Units

As an aid to convenient preliminary selection of gear units for any specific application the tables illustrated above from Farrel Catalog No. 438 will be found highly useful.

Table 1 shows service factors for uniform, moderate shock and heavy shock loads for three types of prime movers and for intermittent, continuous single shift and 24-hour operation. Table 2 shows load characteristics, arranged by types of equipment. Rating tables then provide easy preliminary choice of unit size, of correct thermal and mechanical rating, according to power required, input speed and ratio.

For special applications involving extreme repetitive shock and for applications where exceedingly high energy loads must be absorbed, Farrel engineers are always available for consultation and coöperation in selecting the proper service factor and choosing the unit size best suited to individual needs.

The flexibility of design of Farrel Gear Units, as well as the advantages of Farrel-Sykes continuous tooth herringbone gears offer the designer a wide range of latitude and a resulting exactness of detail not otherwise available. For more particulars and a copy of Catalog No. 438, address:

FARREL-BIRMINGHAM COMPANY, INC.
366 VULCAN STREET BUFFALO, N. Y.

FARREL SYKES GEARS — *The Gear with a Backbone*

been reclaimed, virtually from the scrap pile, and have been converted into modern facilities that add 160,000 net tons of vitally needed pig iron to the total annual production of the plant.

The Hanna Furnace Corporation is one of the country's best known producers of merchant pig iron which, in addition to its normal industrial uses, has scores of direct and indirect defense applications. The company also produces pig iron that is to be further processed into steel by other subsidiaries of National Steel Corporation.

CIRCUIT BREAKER FOR REPETITIVE CYCLES

▲ Designed especially for use in industrial, central station, or power plants where operation under repetitive duty cycles is required, a new and compact circuit breaker is announced by the Westinghouse Electric and Manufacturing Company. The new type DK breaker is available in 15,000 and 25,000 ampere interrupting capacities in all standard current ratings from 15 to 600 amperes for operation on one, two, three, or four pole 600 volt a-c. or 250 volt d-c. circuits.

The new breakers are equipped with a rotary type, removable operating

handle for controlling the breaker manually. In addition electric operation can be provided by a motor mechanism and a shunt trip. The motor operating mechanism is a single enclosed unit in itself. It can be removed by taking out only three bolts. Main contacts are of silver alloy and employ a self-wiping action. "De-ion" arc quenchers minimize burning on the main and the arcing contacts.

These breakers are available in four different forms; an open-type and three forms for enclosed applications. The standard enclosed breaker consists of an open-type unit mounted in a sheet-metal housing. Studs are exposed at the rear when mounted on existing framework, or switchboards, or other apparatus where only the front needs to be enclosed. The second enclosed type is similar except that a pull box for wall mounting is included. Third type is for use when the breaker is to be mounted on a flush type dead front switchboard.

Available accessories for these breakers include oil-suction magnetic, or thermal-magnetic overload trip units which are adjustable for minimum tripping.

For further information on the new type DK air circuit breakers, write department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

CROUSE-HINDS CONDULETS
for uninterrupted service

Now, when the demands of the defense program call for greater and still greater production, shutdowns caused by either equipment failure or sabotage can be disastrous. This is no time to take chances. In remodeling or expansion plans, specify Crouse-Hinds **CONDULETS**. Then you can be sure that these sturdy conduit fittings and enclosures will give your electrical system maximum protection against tampering and accidental electrical failures.

CONDULETS—The standard of quality in the field of conduit fittings.

Type GUSC Explosion-Proof Line Starter Conduilet
Padlocked in "off" position

Type FS Vaportight Switch Conduilet, Key Operated

Type OFC Explosion-Proof Push Button Station Conduilets
With padlock

Type EPC Explosion-Proof Combination Line Starter Conduilet — Air Break
Handle Padlocked

Type WMK Weather Resistant Safety Switch Conduilet
Cover and handle may be padlocked together

Type ZT Safety Switch Conduilet
Double padlock protection

A Nationwide Distribution Through Electrical Wholesalers

CROUSE-HINDS COMPANY
SYRACUSE, N. Y., U. S. A.

Sales Offices: Birmingham — Boston — Chicago — Cincinnati — Cleveland — Dallas — Detroit — Houston — Kansas City — Los Angeles — Milwaukee — Minneapolis — New York — Philadelphia — Pittsburgh — San Francisco — Seattle — St. Louis — Washington
Resident Salesmen: Albany — Atlanta — Baltimore — Buffalo — Charlotte — Denver — Louisville — New Orleans
CROUSE-HINDS COMPANY OF CANADA, LTD., *Main Office and Plant:* TORONTO, ONT.

TOOLS AID MAINTENANCE

▲ A convenient, versatile electric hand tool, called the Whiz, offers an excellent means of speedy accomplishment for the many miscellaneous jobs encountered in mills and shops. Weighing less than 3½ lb., this tool may be used with a wide range of accessories for drilling, grinding, sanding, wire-brushing, polishing, sawing, etching, engraving, etc. In the standard model, the frame is die cast, of light weight, and the three-jaw, coil spring chuck has ¼ in. capacity. There is ample power for almost any duty which might be imposed, and the ball-bearing thrust insures smoothness of operation. The two-speed model offers a normal speed and a high speed in a single unit. Both models work on 110 volt a-c. or d-c. This all-purpose tool, designed for maximum life and accuracy, is manufactured by Paramount Products Company, 545 Fifth Avenue, New York.

OVERHEATED WORKMEN

Cost you more than

TRUFLO FANS

Truflo Fans PAY OFF by making workmen cooler, more comfortable. The result is increased efficiency, more profits for you.

All Truflo Fans are constructed to give the utmost in service at minimum cost. One-piece aluminum alloy propellers supply MORE air per h.p. . . . perfectly-balanced blades assure longer motor life . . . extra strong frames stand up longer under hard use.

Many mills throughout the country have found that efficiency gained as a result of using Truflo Fans more than pays the cost. Put Truflo Fans on *your* payroll now!

TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 inch sizes.

PORTABLE COOLING FANS

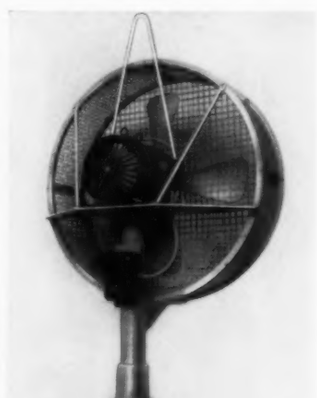
CRANE CAB FANS • WALL FANS

EXHAUST FANS • BLOWERS

ROOF VENTILATING FANS

PENT HOUSE FANS

Write for Illustrated Literature



TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

TRUFLO FAN COMPANY

554 MAIN ST., HARMONY, PA.

NEW BREAKER FOR USE IN SWITCHING SERVICE

▲ A new 230 volt industrial Multi-Breaker—at little more than the cost of a type A switch—is announced by Cutler-Hammer, Inc.

This new breaker affords exceptionally economical application as a motor circuit switch or service disconnect switch. It is fuseless, with bi-metallic strip actuation, visible trip indication, and trip free lever. It is quick make and quick break, with a rated capacity of 230 volts from 15 to 100 amperes, available in 3 pole, 3 pole solid neutral or 4 pole solid neutral types. Calibration is set at the factory and cannot be tampered with. The breaker is completely enclosed and semi-dust-tight. Front access and operation make this breaker convenient, compact and economical of space.

NEW PUBLICATION COVERS AVIATION

▲ "Aerosphere—1941," as the name implies, covers the more important spheres of activity in the field of aviation throughout the world. It is an annual intended to serve as a complete and convenient reference on the subject, and the rapid growth in aviation activity during recent years makes this volume almost indispensible to those engaged or interested in this progressive industry.

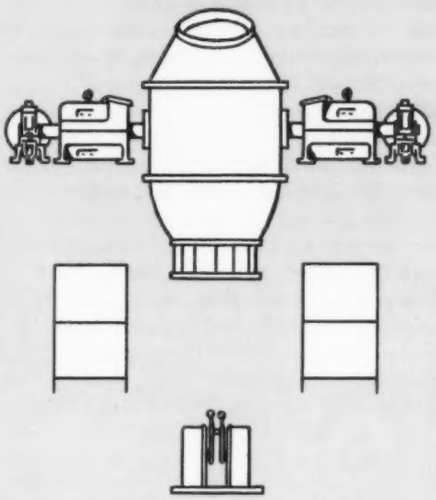
The book, of approximately 900 pages, is divided into four sections. The first section is devoted to modern aircraft, all known current types of aircraft produced throughout the world being described and illustrated in alphabetical order.

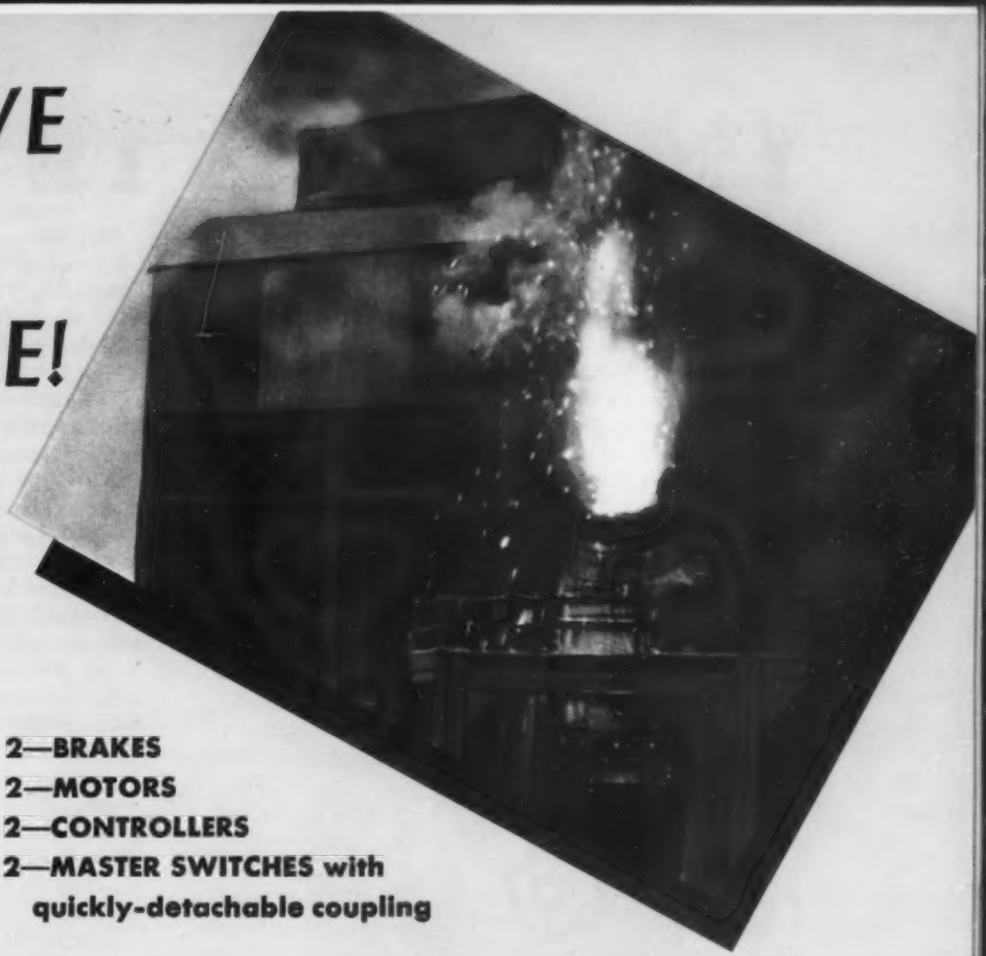
The second section of the book contains in condensed form the available information on all modern aircraft engines produced throughout the world.

Section three includes statistics of the industry which are often desired, while the fourth section is devoted to a world-wide aircraft buyer's guide arranged for convenient use.

Edited by Glenn D. Angle, the book represents a work of considerable magnitude, and should fill a need which has existed for some time. It is published by Aircraft Publications, 370 Lexington Avenue, New York.

A DUAL DRIVE *for* SAFETY'S SAKE!





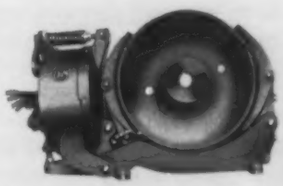
2—BRAKES
2—MOTORS
2—CONTROLLERS
2—MASTER SWITCHES with quickly-detachable coupling

but only TOTALLY SAFE *when* PROTECTED *by the* EC&M *Patented System of* CONVERTER CONTROL

BESSEMER Converters are usually operated by two motors, connected through the gearing, to tilt the converter into various positions required for charging, blowing or pouring. The motors are usually of a size sufficient to permit emergency operation by one motor should the other motor fail and each is equipped with a magnetically-released, spring-set holding brake.

The EC&M Patented Control System—with series-wound Brakes, each Brake equipped with 2 separate windings for positive release of both brakes in an emergency should one motor become disabled—is the last word in control for Bessemer Converter and Hot Metal Mixer Tilt Motions. There is nothing safer. If a fault occurs in either circuit—in the brake, the motor or the controller—the other circuit maintains operation until the safe position of the converter is reached and this is accomplished without any delay—or any time lost to operate knife, disconnect or transfer switches.

Besides eliminating the danger of metal spillage in an emergency, this EC&M Patented Control System, No. 1,899,586, simplifies the controllers, the wiring between the motors and the control and makes the installation not only lower in cost but easier to maintain. We invite you to discuss this system of control for Converters and Hot Metal Mixers with us.



EC&M Type WB Brake with 2 separate windings, one for each motor.

EC&M Type NT Double Master Switch, mechanically connected by quickly-detachable coupling. Arranged for spring-return to the off position.

Typical EC&M TIME-CURRENT Controller for Bessemer Converter Service. Of the Reversing-Plugging Type, usually with Armature Shunt Slow-down on first point.

THE ELECTRIC CONTROLLER & MFG. CO. CLEVELAND, OHIO

HEAVY DUTY MOTOR CONTROL FOR CRANES, MILL DRIVES AND MACHINERY • BRAKES • LIMIT STOPS • LIFTING MAGNETS AND AUTOMATIC WELD TIMERS.

THE ELECTRIC CONTROLLER & MFG. CO. Cleveland, Ohio

ITEMS OF INTEREST

T. R. Rhea has been appointed as engineer of the chemical section, a new section in General Electric's Industrial Engineering department. The chemical section has been established to carry on activities which heretofore have been a part of the work of the mining section of the G-E industrial engineering department.

Mr. Rhea was born in Bonham, Texas. He enlisted in the U. S. Army in 1917, spent about six months at Texas A. & M. as part of his training for service overseas, and then went to France with the A.E.F. After the World War, he returned to the United States and attended Tulane University for two years, although he never had been to high school. Mr. Rhea then went

T. R. RHEA

to the Massachusetts Institute of Technology and was graduated in 1924 with the B.S. degree in electrical engineering.

In 1924, Mr. Rhea entered the employ of General Electric at Schenectady as a student engineer on the test course. One year later he was transferred to the company's advanced engineering course, concurrently doing post-graduate work in night classes at Union College. In 1929 that college awarded him a master of science degree in electrical engineering.

While on the advanced engineering course, Mr. Rhea spent part of 1926 on outside construction work in New York. The following year he was transferred to Schenectady where he entered the Aeronautics and Marine Engineering department, remaining there until 1930 when he joined the Industrial Engineering department.

In 1935, Mr. Rhea was sent to the company's industrial department at the Pittsburgh office as application engineer. He was transferred to the G-E industrial engineering department at Schenectady in 1940, and was assigned to application engineering in connection with chemical industry application problems.

He holds several patents, most of them concerned with applications of electric equipment to steel mills.

Delbert B. Geeseman has been appointed the general superintendent of Canonsburg Works, the tin plate manufacturing plant recently acquired by Carnegie-Illinois from Standard Tin Plate Company.

Mr. Geeseman, who has been Canonsburg manager for Standard Tin Plate since 1928, was born at Gibsonburg, Ohio, July 7, 1881. After graduation from college with an engineering degree, he entered the tin plate industry with Continental Can Company at Chicago, and in 1919 was transfered to the Canonsburg Works as plant engineer. He was appointed plant manager in August, 1928, and district manager in 1930.

Mr. Geeseman is a mamber of the Association of Iron and Steel Engineers, American Iron and Steel Institute and the Engineers' Society of Western Pennsylvania.

Otto L. Weber has been made superintendent of industrial relations at Edgar Thomson Works, Carnegie-Illinois Steel Corporation, Braddock. He comes to the Pittsburgh district from the Gary, Indiana, works of the corporation.

Mr. Weber was born at Chicago, August 24, 1892, and attended Armour Institute and the Universities of Chicago and Wisconsin. He was first employed at Gary Works as a blue printer in 1908 and has since had wide experience in steel plant operations. His service includes work in the electric, rolling, coke oven, mechanical, maintenance and general departments of Gary Works. Since April 1, 1939, he has been assistant to the maintenance division superintendent in charge of personnel matters.

Victor H. Lawrence is now associated with the Otis Steel Company in the capacity of assistant to the president.

Mr. Lawrence graduated in civil engineering at Lawrence University and finished his schooling in metallurgy at the Carnegie Institute of Technology and the graduate school of the University of Pennsylvania.

From 1917 to 1919 he was associated with the Minnesota Steel Company and the Mayville Iron Company in connection with the construction of their steel works at Duluth and a coke works and blast furnace at Mayville.

From 1920 to 1926 Mr. Lawrence served as assistant to the works manager of Jessop Steel Company, Washington, Pennsylvania, having charge of its engineering and metallurgical departments and superintending the construction of its new hot rolled and cold finishing bar mills.

He became associated with the Allan Wood Steel Company, Conshohocken, Pennsylvania, in 1926 as metallurgical engineer, and later became assistant to the executive vice president, in which capacity he served to date.

J. B. Walker has been made sales manager of the transportation and generator division of Westinghouse Electric and Manufacturing Company.

Born in Dardanelle, Arkansas, Mr. Walker was graduated from the Dardanelle High School and then from the University of Arkansas in 1925 with a bachelor of science degree in electrical engineering. He has been employed by Westinghouse in sales positions since his graduation, first as a graduate student and then as a central station sales correspondent. In 1939 he was appointed manager of the generator section in the transportation and generator division, continuing in that position until named sales manager for the entire division. (*Please turn to page 93.*)

Frank R. Burnette has been appointed as assistant chief engineer, Carnegie-Illinois Steel Corporation. Associated with subsidiary companies of United States Steel Corporation for many years, Mr. Burnette has been construction superintendent for Carnegie-Illinois since November 1, 1939.

Mr. Burnette was first employed at the Farrell, Pennsylvania, Works of the former Carnegie Steel Company in 1905 and three years later entered Ohio Northern University, where he was graduated with a degree in civil engineering in 1910. He joined Illinois Steel Company as inspector of construction at Gary, Indiana, after graduation, and for the next four-year period was chief civil engineer for the Southern Aluminum Company at Whitney, North Carolina. He joined American Steel and Wire Company in 1916 and successively became assistant coke works superintendent, superintendent of construction and assistant chief engineer. Mr. Burnette joined the Carnegie-Illinois Steel Corporation as construction superintendent November 1, 1939.

Mr. Burnette is a member of the Association of Iron and Steel Engineers, American Society of Civil Engineers, and Eastern States Blast Furnace and Coke Oven Association.

Joseph Kinney, Jr., is now president of Kinney and Askew, Ltd., 415 Lexington Avenue, New York, specializing in management engineering and industrial public relations. Mr. Kinney has been identified for some ten years with the United Engineering and Foundry Company of Pittsburgh and with its affiliate, United International of Paris, France. Associated with him in the new company is **Theodore J. Kauffeld,** formerly chairman and managing director of both Inter-Continental Engineering Company Ltd. and Steelworks Designs Ltd. of London, England, and recently elected vice president of American Type Founders, Inc., who will serve on the Board of Directors and will place at the disposal of the firm in an advisory capacity his experience in mill construction and management. **Dean Askew,** treasurer of the company, was formerly associated with the General Motors Corporation. In addition to its own staff, the firm has organized an outside staff of consultants experienced in special phases of engineering, management and public relations, which will function as occasion may demand.

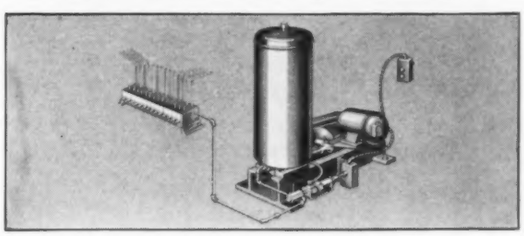
William T. Dean, for the past ten years superintendent of the 44 in. blooming and 36 in. slabbing mills in the Gary Works of the Carnegie-Illinois Steel Corporation, has resigned to become district manager in the Chicago area for the Bloom Engineering Company of Pittsburgh, Pennsylvania.

In addition to the past ten years' experience in the operation of mills and furnaces, Mr. Dean has had many years in the design, construction, and operation of nearly all types of metallurgical furnaces, and has received some fifteen patents relating to metallurgical subjects.

Mr. Dean received his collegiate and technical training at the University of Iowa and Armour, now Illinois Institute of Technology. Mr. Dean has been a member of the Association of Iron and Steel Engineers since 1907.

Cut production delays...Equip your machines with

LINCOLN CENTRO-MATIC LUBRICATING SYSTEMS



New system supplies a measured amount of lubricant to every bearing from a central source

The Lincoln Centro-Matic System consists of a number of Centro-Matic Injectors—one for each bearing—and a suitable Centro-Matic lubricant pump. The injectors may be grouped in one location or located separately at each bearing. In either arrangement only a single lubricant supply line is required. The lubricant pump may be hand or power operated—Power operated Systems may be semi-automatic or full automatic.

There is a Centro-Matic System for every type of machinery using grease lubrication . . . Get complete information. Write today for Bulletin 888. 141-4

LINCOLN ENGINEERING COMPANY
PIONEER BUILDERS OF LUBRICATING EQUIPMENT
ST. LOUIS, MO.

WORLD'S GREATEST all around ELECTRIC TOOL

DRILLS—GRINDS—SANDS
SAWS—POLISHES
SHARPENS—CARVES

The new WHIZ ELECTRIC TOOL is the handiest power tool ever made. A rugged tool for power and precision work. Drills through ¼ inch iron plate in 42 seconds or engraves intricate designs. Handles any material: Metals—Woods—Alloys—Plastics—Glass—Steel—etc. Saves time. Eliminates labor. Plug into any socket AC or DC, 110 volts. Chuck ¼ inch capacity. Ball bearing thrust. Powerful, triple-geared motor. STANDARD MODEL, with Normal Speed (uses 200 different accessories, instantly interchangeable). **Price only $7.95.**

The only DRILL-TOOL with a full year's guarantee

FREE Accessory outfit (Value $2) includes set of drills, mounted 1½ inch grinder, sanding discs, cutting wheels, mounted brush, polishing wheel, carving burr, etc. FREE with each too ordered NOW. We pay postage.

10-DAY TRIAL—MONEY BACK GUARANTEE

PARAMOUNT PRODUCTS CO.

Dept. 8-RAS 545 Fifth Ave. New York, N. Y.

All ACTIVITIES

CLEVELAND PUBLIC

Tuesday, SEPTEMBER 23

Iron and Steel Exposition—9:00 A.M.–10:00 P.M.

9:00 A.M.—REGISTRATION—Main Lobby

Chairman:
T. B. McELRAY
Superintendent, Light and Power
Carnegie-Illinois Steel Corporation
Youngstown, Ohio

Vice-Chairman:
E. C. McDONALD
Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

9:00 A.M.—LADIES' REGISTRATION—Hotel Statler, Parlor K.

9:15 A.M.—BUSINESS SESSION—Club Room B

Chairman:
W. A. PERRY
Superintendent, Electric and Power Department
Inland Steel Company
East Chicago, Indiana

Vice-Chairman:
J. L. MILLER
Assistant Chief Combustion Engineer
Republic Steel Corporation
Cleveland, Ohio

9:30 A.M.—ELECTRICAL ENGINEERING DIVISION—Club Room B

Chairman:
K. E. DINIUS
Electrical Engineer
Carnegie-Illinois Steel Corporation
Chicago, Illinois

Vice-Chairman:
H. R. FORD
Electrical Engineer
Wheeling Steel Corporation
Steubenville, Ohio

"Report of Crane Specification Committee," by F. W. Cramer, *Electrical Engineer*, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

"Ore Bridges," by George Wolfe, *Special Engineer*, Dravo Corporation, Pittsburgh, Pennsylvania.

"Transmitting Torque from Electric Motors," by A. M. MacCutcheon, *Vice President in Charge of Engineering*, Reliance Electric and Engineering Company, Cleveland, Ohio.

1:30 P.M.—MECHANICAL ENGINEERING DIVISION—Club Room B

Chairman:
J. D. JONES
Chief Engineer
Youngstown Sheet and Tube Company
Youngstown, Ohio

Vice-Chairman:
J. E. GRAF
Assistant Chief Engineer
Jones and Laughlin Steel Corporation
Pittsburgh, Pennsylvania

"Development of New Rolling and Steel Capacity at Steel Company of Canada," by C. H. Hunt, *Consulting Engineer*, Pittsburgh, Pennsylvania.

"Design and Operation of the Bessemer Convertor," by D. R. Loughrey, *Assistant General Superintendent*, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.

"Rolling Pressures in the Strip Mill," by M. R. Stone and J. I. Greenberger, United Engineering and Foundry Company, Pittsburgh, Pennsylvania.

1:30 P.M.—WELDING ENGINEERING DIVISION—Club Room A

Chairman:
A. W. STEED
Maintenance Superintendent
American Rolling Mill Company
Middletown, Ohio

Vice-Chairman:
STANLEY GRAND-GIRARD
Electrical and Mechanical Superintendent
Sharon Steel Corporation
Sharon, Pennsylvania

"Advanced Methods of Welding," by E. W. P. Smith, *Consulting Engineer*, Lincoln Electric Company, Cleveland, Ohio.

"Classification of Modern Welding Equipment," by C. H. Jennings, Research Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"Welding in Cold Strip Processing," by J. H. Cooper, *Welding Engineer*, Taylor Winfield Company, Warren, Ohio.

12:30 P.M.—LADIES' LUNCHEON—Canary Cottage, Chagrin Falls, Ohio. Buses leave from Hotel Statler.

10:00 P.M.—EXHIBITORS' DANCE—Grand Ball Room, Hotel Statler—Informal

Wednesday, September 24

Iron and Steel Exposition—9:00 A.M.–10:00 P.M.

9:00 A.M.—COMBUSTION ENGINEERING DIVISION—Club Room B

Chairman:
A. J. FISHER
Fuel Engineer
Bethlehem Steel Company
Sparrows Point, Maryland

Vice-Chairman:
P. C. SINGLETON
Assistant Steam Engineer
Inland Steel Company
East Chicago, Indiana

"Recent Advances in Control of Multi-Fuel Fired Furnaces," by J. C. Vaaler, Askania Regulator Company, Chicago, Illinois.

"Modern Designs of Annealing Covers," by Lee Wilson, *President*, Lee Wilson Engineering Company, Cleveland, Ohio.

"Submerged Heating for Pickling Baths," by W. G. See, The Submerged Combustion Company of America, Inc., Hammond, Indiana.

9:00 A.M.—OPERATING PRACTICE DIVISION—Club Room A

Chairman:
C. P. BETZ
Assistant Manager
Hanna Furnace
Great Lakes Steel Corporation
Ecorse, Michigan

Vice-Chairman:
P. V. MARTIN
Assistant Divisional Superintendent
Coke Plant and Blast Furnace
Carnegie-Illinois Steel Corporation
Gary, Indiana

TECHNOLOGY DEPT.

Iron AND Steel ENGINEER

PUBLIC LIBRARY
SEP 1 1941
DETROIT

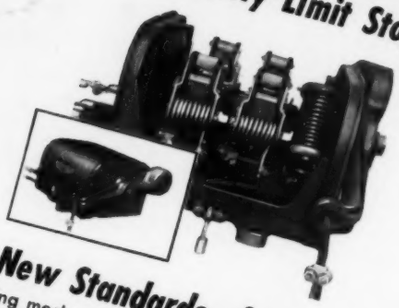
ENGINEERING SERVICE
TO THE IRON AND STEEL
INDUSTRY SINCE 1907

1010 EMPIRE BUILDING — *September, 1941* — PITTSBURGH, PENNA.

KEEPING THEM ROLLING
Timken Roll Neck Bearings are keeping America's steel mills rolling to produce more and more high grade steel for defense armament. Likewise Timken Bearings are keeping the fighting equipment itself—the guns and tanks and armored cars and trucks and airplanes—rolling swiftly, smoothly, dependably.
The same trio of Timken Bearing qualities—precision, strength, endurance—serve both needs with utmost efficiency.
THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO
Manufacturers of Timken Tapered Roller Bearings for automobiles, motor trucks, railroad cars and locomotives and all kinds of industrial machinery; Timken Alloy Steels and Carbon and Alloy Seamless Tubing; and Timken Rock Bits.
TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
TAPERED ROLLER BEARINGS

SEE THIS IMPORTANT C-H STEEL MILL CONTROL AT THE IRON AND STEEL SHOW

The Crane Safety Limit Stop That Sets New Standards of Performance



1. Tripping mechanism entirely enclosed—cannot be rendered inoperative by rain, snow, ice, dirt, or falling objects.
2. Quick make and break tripping mechanism—no possibility of stopping in intermediate position after having started from normal.
3. Gasketed cover keeps weather and water out.
4. Provisions for mounting in four quadrants.
5. Contacts and heavy-duty blow-outs mounted on slate support with no horizontal dust-collecting surfaces between live parts and ground.

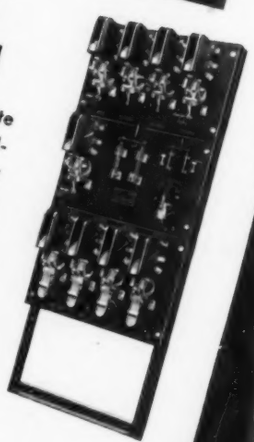
The Most Important Motor Control Advance of a decade . . . UNITROL

Unitrol is a new idea in Motor Control. It is a new unit-type of standardized Motor Control construction which permits all needed types of control devices to be easily organized into a complete enclosed sectionalized Motor Control Center. Unitrol comes to you complete . . . either with all wiring, busses, terminals, and interconnections already made . . . or with provisions for wiring it "on the job". It may be changed, extended, or contracted later on, just as easily and economically as it was first built up. It saves space, time, trouble, worry, and inconvenience up and down the line; and its installed cost is less than the cost of any "home-made" substitute.

The World's Largest Lifting Magnet

The giant 77" Cutler-Hammer Supermagnet is the world's largest and most powerful lifting magnet. It's only one of the many types giving super-service in the nation's leading steel mills. Whether you plunge supermagnets through live steam to pick up red-hot crop ends, or work them outside in subzero weather, in rain or snow, they stand up day after day, year after year, giving you unfailing dependability to maintain 24-hour schedules. And at the same time you get, dollar for dollar, the greatest lifting power and efficiency to be had in the lifting magnet field.

The Outstanding Steel Mill Motor Control—Ltl



No heavy duty motor control has ever quite been able to equal Cutler-Hammer in its ability to provide automatically and unfailingly the correct time-current torque requirements for each specific load. Ltl is simple, there are few moving parts . . . it simply takes advantage of a fundamental law of electricity at work. That's the one reason why you find C-H Ltl on the toughest mill jobs . . . where production is vital . . . where dependability must be more than a boast. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee, Wisconsin. Associate: Canadian Cutler-Hammer, Ltd., Toronto.

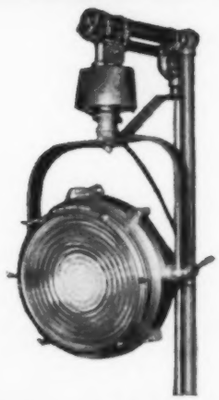
CUTLER-HAMMER
MOTOR CONTROL
C-H

CLEVELAND PUBLIC AUDITORIUM
Cleveland, Ohio September 23-25, 1941
BOOTHS 46, 47, 58 AND 59

This simple installation solves many floodlighting problems

Mill men facing the problem of efficient floodlighting for night operations or protective purposes will find the solution of many installation problems in Pyle-National floodlight projectors designed for suspension from Thompson Lamp Lowering Hangers. In the night view above note that projectors are spaced for efficient and uniform illumination of a large area, but the pole mounting does not encroach upon valuable track and driveway space. Projectors are mounted on 40-foot crossarms at the top of 75-foot poles. Servicing is safely done on the ground, facilitating cleaning and re-lamping. Projectors return to original adjustment when raised; any changes in radial or vertical adjustment are made on the ground.

Pyle-National floodlight projectors for use with Thompson Hangers are being used for many different types of mill lighting installations. They avoid the hazard of maintenance work on tall structures and allow efficient lighting with simple and economical installation methods. Write for Bulletin No. 2100 giving complete floodlight data.



Pyle-National 14-inch floodlight projector with circular divergence lens, and Thompson Lamp Lowering Hanger Unit for pole mounting.

PYLE-NATIONAL

The Pyle-National Company, *General Offices and Works,* 1334-58 North Kostner Avenue, Chicago, Illinois • *Offices:* New York, Baltimore, Pittsburgh, St. Louis, St. Paul, San Francisco.

CONDUIT FITTINGS • LOCOMOTIVE ELECTRICAL EQUIPMENT • FLOODLIGHT PROJECTORS

MATHEWS CONVEYERS

Keeping Defense Materials *Moving*

● In the Industrial Plants of America, Mathews Conveyers are helping to speed production of Coils and Sheets, Shells and Cases, Forgings, Castings, and a wealth of material vital to America's Defense.

In times like these there is no substitute for Experience. Mathews Engineers have it and are putting it to work.

FACILITIES GREATLY EXPANDED

We believe in the National Defense Program and are fully cooperating under the Priorities System. The capacity for production of Mathews Conveyers has been increased 70% to care for Defense requirements and, materials permitting, civilian requirements as well.

MATHEWS CONVEYER COMPANY, ELLWOOD CITY, PENNA.

FIELD ENGINEERS AND SALES OFFICES LOCATED IN 30 INDUSTRIAL CENTERS

How about your equipment, Mr. Superintendent?

Office of THE GENERAL SUPERINTENDENT

TO: Superintendents,

DEPT: All Departments

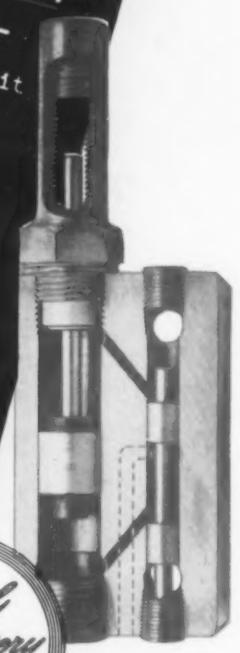
NO REPLY NECESSARY ☐

PLEASE REPLY ☒

Please check your equipment immediately and see what is necessary to put it into first-class condition to carry peak loads.

Be sure to check your present methods of lubrication, and send me a list of the equipment on which centralized systems could be installed.

We wish to take advantage of these times, because it will be just as important for us to be able to compete successfully later on, as it is for us to maintain top production now.



Look to your bearings now. Install Farval Centralized Systems with absolute assurance of better, lower-cost lubrication—with never a shutdown due to lack of oil or grease.

Farval not only helps you maintain full production, but quickly pays back its cost by:

—reducing power consumption as much as 30%

—increasing life of bearings up to 10 times

—lowering maintenance cost by 75%

—prolonging life of equipment indefinitely.

We suggest you have our Representative check over *your* equipment without obligation on your part. The Farval Corporation, 3270 East 80th Street, Cleveland, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Manufacturers of Automotive and Industrial Worm Gearing.

In Canada: PEACOCK BROTHERS LIMITED

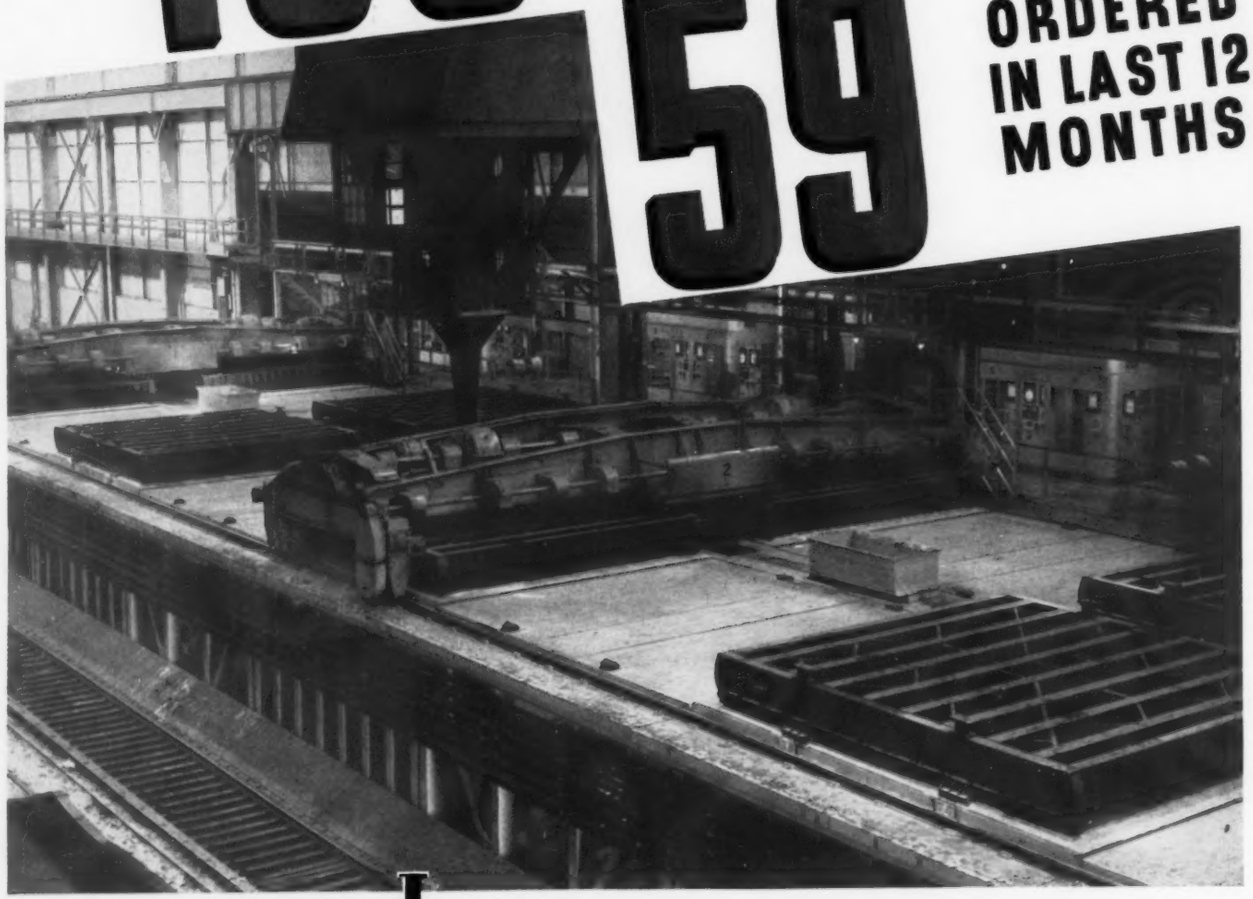
Special Delivery TO EVERY BEARING

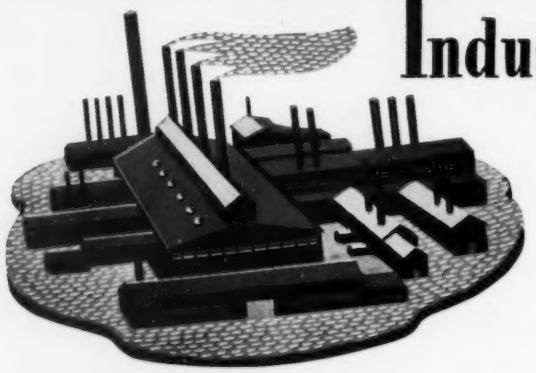
FARVAL

CENTRALIZED SYSTEMS OF LUBRICATION

106 SOLD IN LESS THAN 4 YEARS

59 ORDERED IN LAST 12 MONTHS





Industry goes "all out" for AMCO Pit Furnaces

When introduced four years ago, AMCO Pits established new production, fuel, maintenance and other unprecedented records for ingot-heating.

Today, because of continued refinements and improvements, AMCO Pits provide even greater over-all economies, PLUS 10% further increase in production.

The AMSLER-MORTON COMPANY
FULTON BUILDING • PITTSBURGH, PA.

Schloemann Installations in a plate mill at Pittsburgh

Left—"Motor-Roller" equipped Scale Table

Below—
"Motor-Roller" equipped Shear Depressing Table

EXCLUSIVE ADVANTAGES

of

SCHLOEMANN "MOTOR-ROLLERS"

With the rotating trunnion-type roller housing the driving motor, the necessity for using line shafts, couplings and gear reduction units is eliminated. Simplified table construction is the result, affording free access along both sides of "Motor-Roller" Tables.

Installation of rollers between the housings of Mill Stands and Shear Housings is possible without introducing complicated or weak elements.

Fewer wearing parts provide the ruggedness and dependability essential in mill service with reduced operating and maintenance costs.

Each "Motor-Roller" installation is designed and built for the particular requirements of its application.

SCHLOEMANN

ENGINEERING CORP. PITTSBURGH, PA.
Rolling Mill Machinery Hydraulic Presses

NEW!

EC&M

for D-c Service

of

LINE-ARC

(TRADE MARK)

Design

✓ Check these NEW Features

1 45% Faster than Previous Design.

2 2-position adjustment, permitting over ½" contact-wear.

3 Moment of Inertia of Auxiliary Arm reduced by the use of Single Contact-design results in faster operation.

4 Clamped joints in current-carrying path reduced 25%.

5 More efficient magnetic circuit with bi-polar magnet construction, making the flux effective at both air gaps instead of one. This reduces amount required, keeps leakage flux to minimum and cuts down inductance.

6 Powerful Magnetic Blow-out and large Arc Shield for interrupting highly inductive circuits.

Plus these Proven Features used on all LINE-ARC Contactors

7 Control of the arc by the *LINE-ARC* principle keeps contacts cool, lengthening their life and centers arc between arc shields where it can do no harm.

8 Nitralloy steel pins and bushings in main and auxiliary arms.

9 Continuous capacity operating coils for voltages of 230 volts or less. Will safely withstand 10% overvoltage and will operate satisfactorily on voltages, 20% under rated voltage.

10 Contacts are pure copper, cold-formed by a special process to give high Brinell hardness.

11 Current-carrying shunts are made of individually tinned strands of wire and are of proper length and design to eliminate whip and distribute flexing over entire length.

12 Armature plate insert in main arm is Parkerized for corrosion-resistance.

HEAVY DUTY MOTOR CONTROL FOR CRANES, MILL DRIVES AND MACHINERY • BRAKES • LIMIT STOPS • LIFTING MAGNETS AND AUTOMATIC WELD TIMERS.

THE ELECTRIC CONTROLLER &

MAGNETIC CONTACTOR

600 & 800 Amperes, 8-hour rating

Tested over 19 months in Screwdown Service

•

Used as Line Contactor for 2-80 MC Motors in Series

The arc formed when opening the circuit to these motors is vicious. Due to the high inductance of two motors connected in series, an arc of 12 to 18 inches in length frequently occurs. On the previous line contactor used on this controller, contacts averaged about 300,000 operations before replacement was necessary. The original set of contacts on this new EC&M D-c Contactor operated *nearly 7 times longer*—over 2 million times before being replaced.

HERE is a development of distinction . . . distinctive because it has been exposed to conditions made possible only by the near-capacity operations of steel mills during the past 2 years. Never before in the history of steel making has a new piece of equipment been baptized in the field under such exacting conditions as this new EC&M *LINE-ARC* Contactor has undergone during the past 19 months.

Although all EC&M developments are thoroughly tested both in the laboratory and in the field before they are released for sale, the figures of this test reveal an unparalleled story of new equipment performance on a tough job . . . tough enough under normal conditions but greatly increased due to near-capacity operations.

In January 1940, this EC&M Contactor was installed as the line contactor on a blooming mill screwdown controller operating 2-80 MC Motors in series. The circuit was so arranged that this line contactor would open first when the master switch was brought to the off position to permit this unit to handle the highly inductive arc of the circuit. Thus, the electrical characteristics of the circuit are very severe and the mechanical operations, as shown by the following table, are very high.

ORIGINAL CONTACTS LAST 7 MONTHS COMPARED WITH ABOUT 4 WEEKS CONTACT-LIFE ON PREVIOUS CONTACTOR

Start of operation of EC&M Contactor	Jan. 29, 1940
Original Contacts replaced	Aug. 24, 1940
No. of operations on original contacts	2,080,724
Life of original contacts in days	208
Average No. of operations per day of original contacts	10,003

Greatly improved contact-life is only one indication of the quality of this contactor. Mechanically, it has successfully withstood nearly 6 million operations in this 19-month period—bearings, shunts, etc., being in good condition and capable of many more million operations.

LINE-ARC Blow-out feature designed to handle highly inductive circuits as experienced on this 2-motors-in-series circuit as well as for normal service encountered in single motor circuits. When buying D-c Motor Control, specify EC&M *LINE-ARC* Contactors—a complete line for crane and mill auxiliary service.

Examine it at Booth Nos. 138, 139, 140 & 141 — Iron & Steel Exposition — Sept. 23, 24 and 25, Cleveland Auditorium

& MANUFACTURING CO., Cleveland, Ohio

AIR
LAND
SEA
RAW MATERIALS
MANUFACTURING
TRANSPORTATION

Throttle is *WIDE OPEN*

for Defense

Just as SKF pioneered in the development of antifriction bearings for use on steel mill machinery, so it has pioneered in the application of antifriction bearings on airplanes, tanks, battleships, guns, and other equipment in the front lines of Defense.

SKF has had the throttle wide open for the last 18 months, supplying vast quantities of antifriction bearings for Defense, for transportation, and for the industrial machines that are making newer and deadlier weapons.

Even at the outbreak of the war, SKF sensed an unprecedented demand for antifriction bearings. Manufacturing facilities were doubled. Wing after wing was added. So were new machines. New men. ALL for Defense! And when the green light flashed, "Full speed ahead!" Defense machinery went smoothly into action with SKF precision.

SKF INDUSTRIES, INC., FRONT ST. & ERIE AVE., PHILA., PA.

●TODAY, *there is hardly any type of machine built for Defense that is not equipped with SKF Bearings.*

SKF

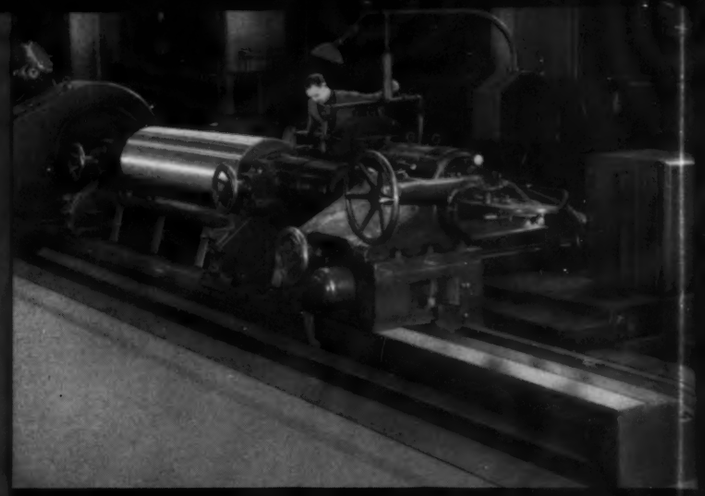
BALL & ROLLER BEARINGS

MESTA

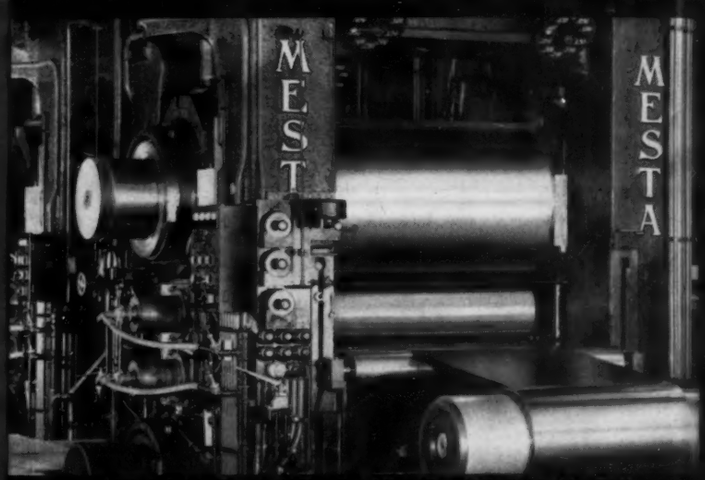
ROLLS

STEEL MILL EQUIPMENT

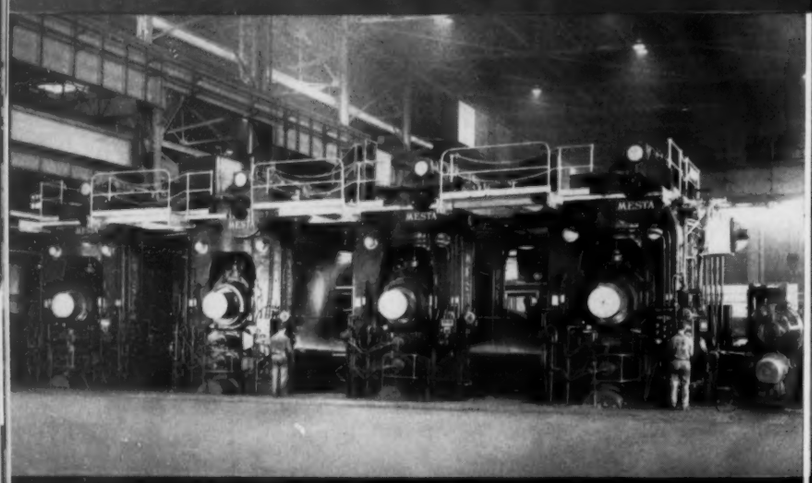
HEAVY DUTY MACHINERY



Mesta 60" Heavy Duty Roll Grinder



Mesta Heat Treated Special Alloy Steel Backing Up Rolls for Four-High Hot and Cold Mills

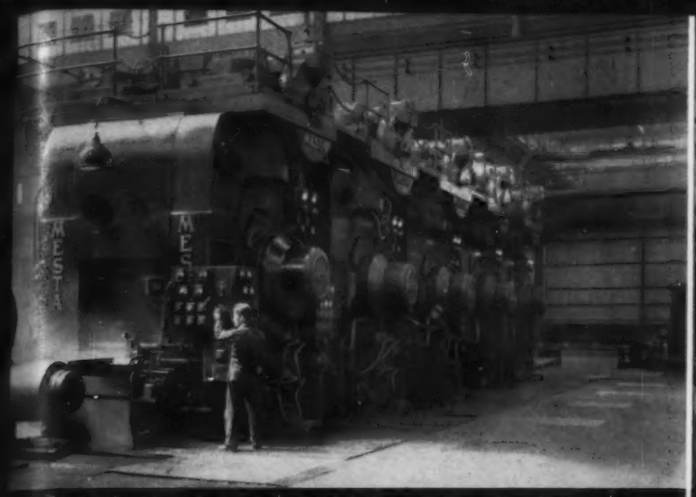


54" Four Stand Tandem Cold Mill for Rolling Thin Sheet Gauges

Mesta Forged Hardened Steel Working Rolls for Cold Mills

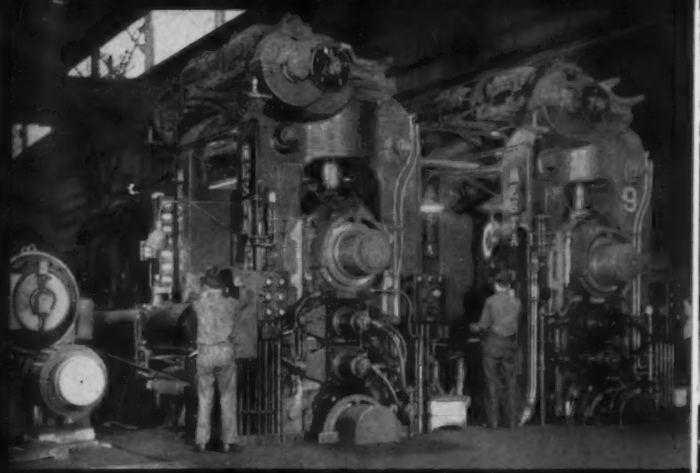
6,000 Ton Pure Hydraulic, Quick Acting Forging Press Forging 100" Ingot

84" Heavy Duty Boring and Turning Lathe



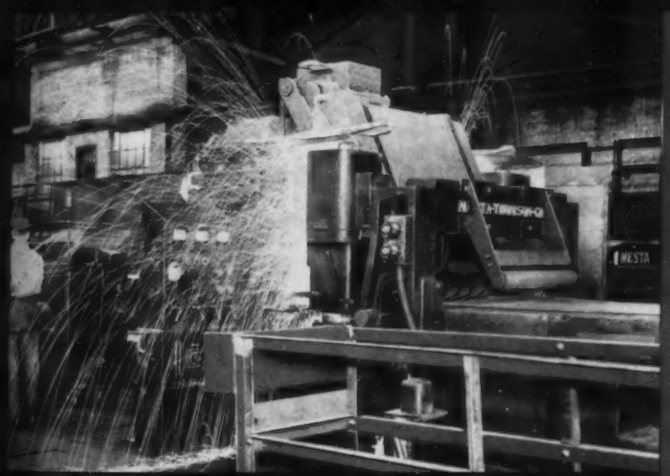
42" Five Stand Tandem Cold Mill for Rolling Tin Plate

Mesta 46" Slabbing-Blooming Mill
with Mesta Patented Electrically Operated Manipulator



42" Twin Stand Skin Pass Mill

Finishing Stands, 80" Four-High Continuous Hot Strip Mill



Mesta-Thomson-Gibb Butt Welder in Mesta Pickling Line

Machining 214,000 Lb Steel Casting on 14' Heavy Duty Planer

MESTA PRODUCTS

are built in the largest unit plant in the world devoted to the production of ROLLS and STEEL MILL EQUIPMENT

COMPLETE ROLLING MILL EQUIPMENT

Bar Mills
Billet Mills
Blooming Mills
Continuous Mills
Merchant Mills
Non-Ferrous Mills
Piercing Mills
Pipe Mills
Plate Mills
Rail Mills
Rod Mills
Sheet Mills
Shovel Mills
Skelp Mills
Slabbing Mills
Four-High Hot Strip Mills
Four-High Cold Strip Mills
Structural Mills
Tin Plate Mills
Tire Mills
Tube Mills
Universal Mills
Wheel Mills

Mesta Patented Flying Shears
Bar Shears
Billet Shears
Bloom Shears
Crop Shears
Hydraulic Shears
Lever Shears
Plate Shears
Slab Shears
Squaring Shears
Steam Hydraulic Shears
Furnace Charging Equipment
Manipulators
Mill Tables
Flexible Couplings
Shear Gauges
Slab Scales
Cooling Beds
Transfers
Conveyors
Pushers
Buggies and Cars
Hot Saws

Cold Saws
Pack Annealing Beds
Annealing Boxes
Gear Drives
Cut and Machine Molded Iron and Steel Gears
Coilers
Coil Boxes
Pilers
Mesta Patented Feed Rolls
Tension Reels
Belt Wrappers
Mesta Patented Sheet Chargers
Electrolytic Cleaning Lines
Mesta Patented Pickling Machines
Continuous Pickling Lines
Processors
Flash Welders
Trimmers and Slitters
Stitching Machines
Straightening Machines
Levellers
Scrap Ballers

ROLLS AND MILL PINIONS

Steel and Alloy Steel Rolls
Mesta Grain Rolls
Chilled and Sand Iron Rolls
"Mesta Special" Alloy Steel Rolls
Mesta Hardened Chill Rolls
Mesta Hardened Grain Rolls
Heat Treated Special Alloy Steel Rolls
Backing-Up Rolls
Forged Hardened Steel Rolls
Cut Tooth Mill Pinions
Machine Molded Mill Pinions

FORGINGS

Open Hearth and Electric Furnace Alloy and Carbon Steel

Large Shafts, Ship Shafts, Billets, Blooms, Piston Rods, Connecting Rods, Locomotive Axles, Reaction Towers, Air Bottles, Boiler Drums, Crankshafts and General Forgings

PRESSES AND EQUIPMENT

Hydraulic and Steam Hydraulic Forging, Bending, and Forming Presses
Large Power Presses
Intensifiers
Accumulators

SPECIAL MACHINE TOOLS

Heavy Duty Table-type Planers
Heavy Duty Post-type Planers
Heavy Duty Pit-type Planers
Heavy Duty Draw-Cut Shapers
Heavy Duty Boring Mills
Gear Planing Machines
Combination Shaping, Boring and Milling Machines
Heavy Duty Boring and Turning Lathes
Trepanning Lathes
Ingot Slicers
Roll Grinders
Roll Lathes
Gear Hobbing Machines

GAS AND STEAM ENGINES FOR BLAST FURNACES, ROLLING MILLS AND POWER PLANTS

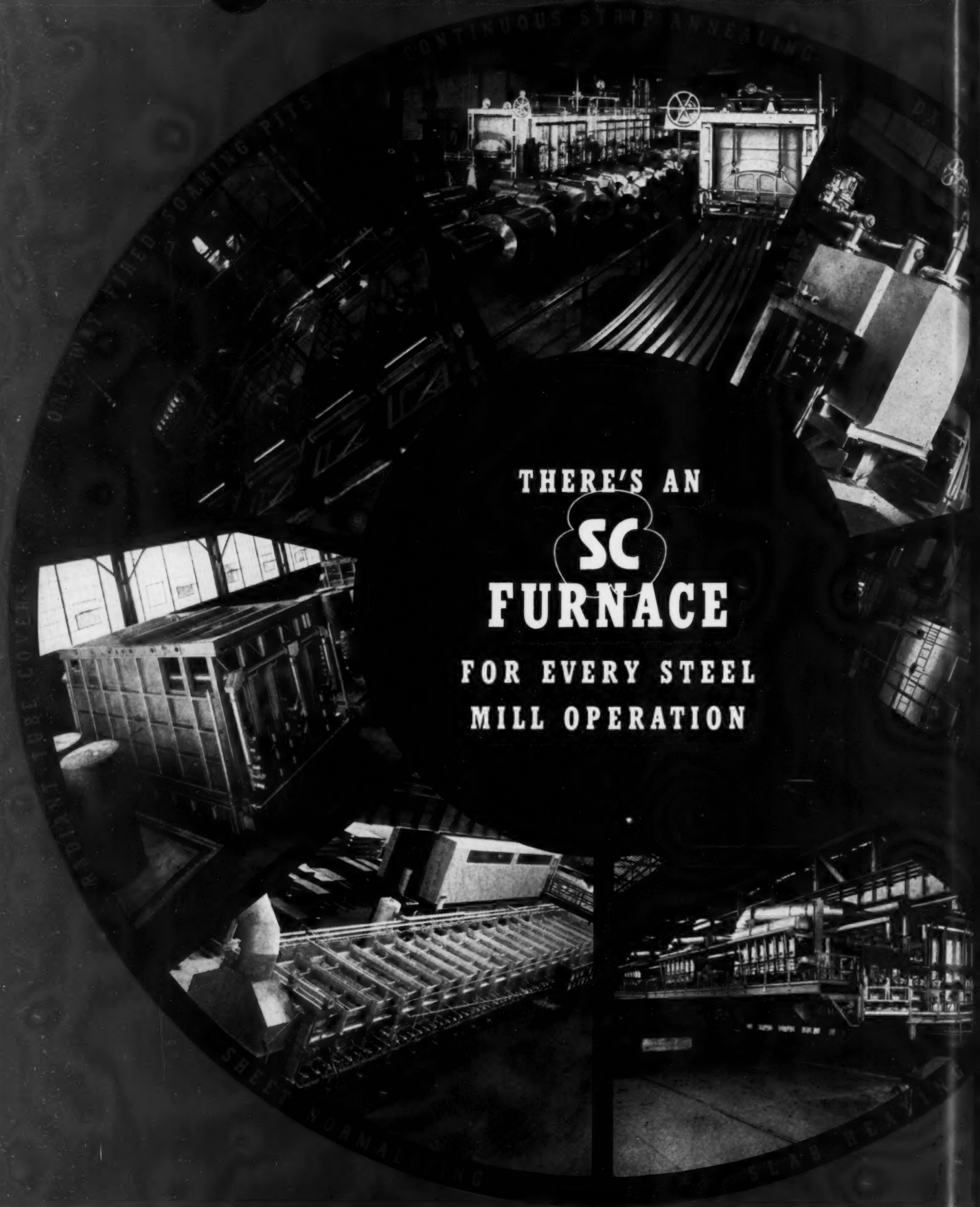
Uni-Flow Engines (Stumpf Patents)
Piston and Corliss Valve Engines
Reversing Engines
Blowing Engines
Barometric Condensers
Air Heads
Air Compressors
Vacuum Pumps
Mesta Automatic Plate Valves (Iverson Patents)

CASTINGS

Acid Open Hearth, Carbon and Alloy Steel Castings and Forging Ingots, Air Furnace Iron Castings, Bronze Castings

MESTA MACHINE COMPANY, PITTSBURGH, PA.

CONSTANT COOPERATION AND



CONTACT WITH THE STEEL MILL FOR

34 YEARS

Only a few short years after the organization of Surface Combustion in 1907 . . . the steel industry was called upon to meet the demands of the first World War. Even then Surface Combustion, through close cooperation with the industry, was able to make numerous important contributions in the design of new furnaces. Outstanding SC developments and installations of that period included what was then the largest continuous furnace for treating 76 mm. shells; the rotary shell nosing furnace; and the direct fired vertical or pit type gun furnace . . . Today, the steel industry is again called upon to meet another emergency. With a background of 34 years of experience and literally thousands of installations in the steel mills, Surface Combustion can now offer immeasurably greater help to the steel industry with its heating and heat treating problems.

Shown at the left are a few typical and recent SC installations. Among the more prominent other types of furnaces developed by SC but not shown are: The walking beam conveyor furnace for heating round billets for piercing into tubing; tube treating furnaces; galvanizing settings, utilizing the SC developed radiant impact burners; continuous shell treating furnaces with walking beam conveyors; and the Char-Mo Atmosphere gas generator for protecting high carbon and alloy steels . . . In short . . . there is an SC furnace for every Steel Mill operation from the time the ingot solidifies to the final heat application.

SURFACE COMBUSTION CORPORATION • TOLEDO, OHIO

"SECURITY FOR AMERICA"

SC FURNACES FOR NATIONAL DEFENSE

WHEREVER HEAT IS USED IN INDUSTRY

SURFACE SC COMBUSTION

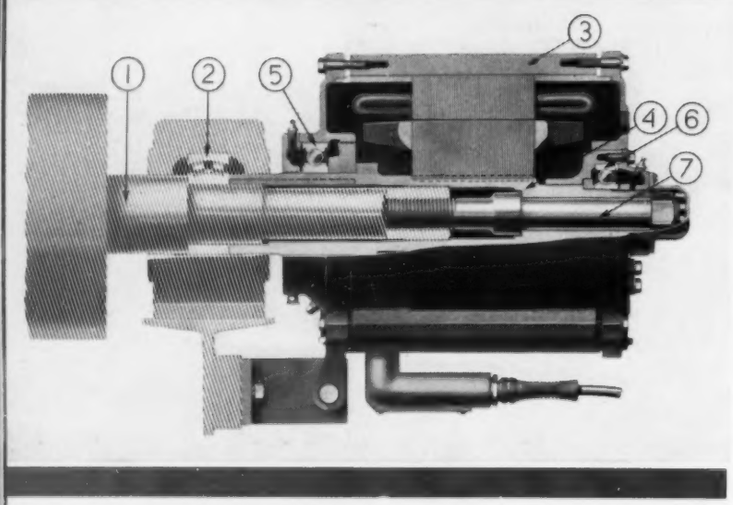
MANUFACTURERS OF INDUSTRIAL FURNACES • JANITROL GAS-FIRED SPACE HEATING EQUIPMENT • AND KATHABAR AIR CONDITIONING SYSTEMS

RELIANCE FLOATING-MOTOR *for* TABLE ROLLERS

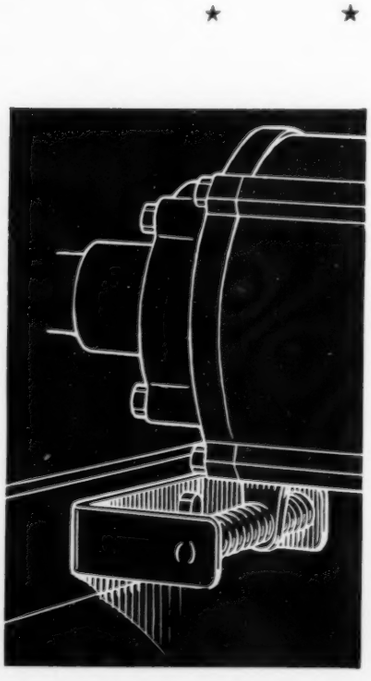
Reliance Floating-motor Drive for Table Rollers. A-c. squirrel-cage, enclosed, watertight, ball bearings, Class B insulation. For extra strength, stator frame is constructed of bar-steel, electrically welded. Motor is mounted with outlet and restraining arm at bottom.

ROLLERS can warp, tables become uneven, but this new Reliance Floating-motor Drive keeps material moving just the same. . . . Gears and couplings are not needed. . . . Roller and rotor become an integral unit on a common set of bearings. There can be no misalignment. . . . Air gaps stay uniform. . . . Mounting the motor on the roller shaft is as simple as applying a gear or coupling. There is no "lining up". . . . Roller and driving motor can be removed from the table as a unit. . . . Table construction is simplified. . . . For both A-c. and D-c.

★ ★ ★



Motor is mounted on the roller shaft (1) in a manner that makes the rotor an integral part of the roller; there can be no relative movement between them. Rotor and roller are carried on the same set of bearings (2). The motor stator (3) is carried from the hollow shaft (4) through ball bearings (5, 6). This avoids any possibility of the rotor being displaced in reference to the stator so that air gaps are kept uniform. In mounting the motor the hollow motor shaft (4) is slipped over the shaft extension of the roller (1). The threaded portion of the jack screw (7) engages the tapped hole in the roller shaft and the motor is drawn into position by turning the jack screw.

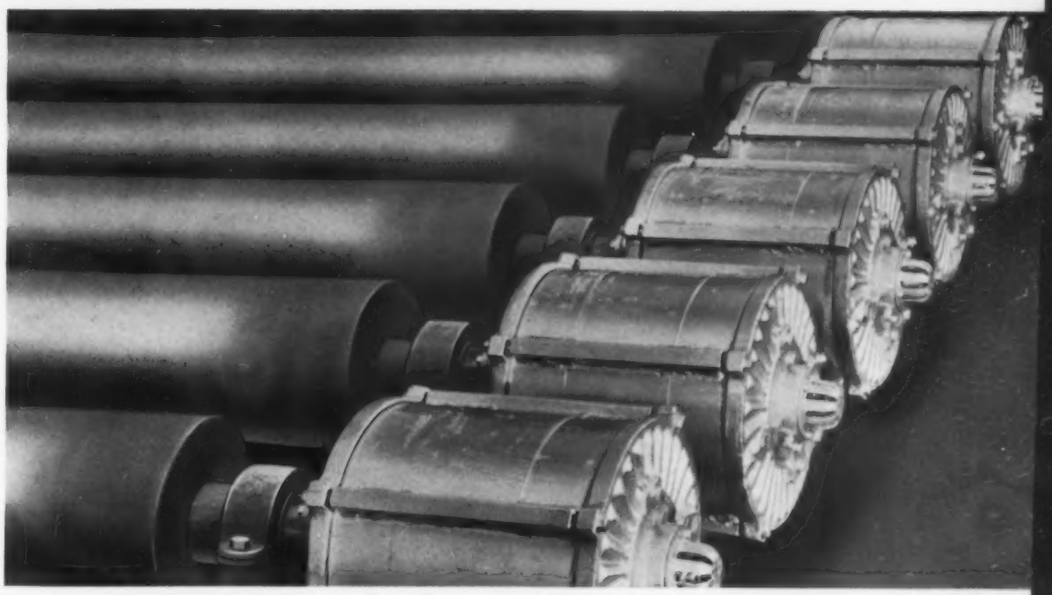


Two coil springs anchored to the table bed prevent rotation of the field frame and through their reaction, compel the rotation of the rotor or armature, and therefore, the roller. The springs not only prevent rotation of the field frame, but also cushion the starting of the motor.

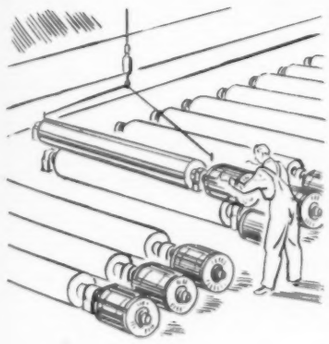
DRIVE

Patent No. 2,198,863

SPEED CONTROL. A-c. Speed variation for table rollers using squirrel-cage motors can be provided by frequency control. **D-c.** For d-c. motors variable-voltage control is used to supply variations in speed. The range in speeds is such that material of various sizes can be handled at the most effective rate.



Runout Table Rollers equipped with Reliance Floating-motor Drive. These units operate successfully even when rollers are warped and mountings are not level. Table and installation costs are less, and so is maintenance. Built for both a-c. and d-c. circuits.



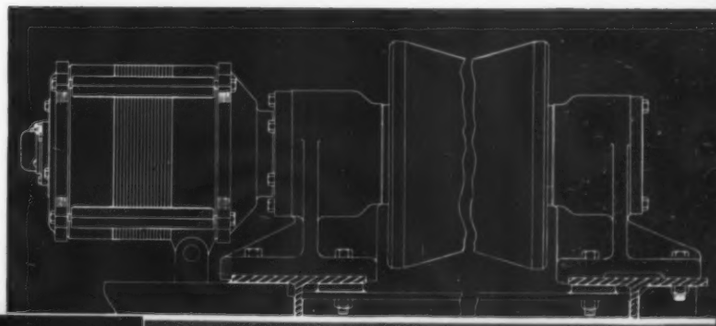
Roller and driving motor can be removed from the table as a unit after disconnecting the flexible leads.

Table construction can be exceedingly simple and inexpensive as the table does not necessarily have to be level.

There can be no misalignment because roller and rotor become an integral unit on a common set of bearings. Troubles with gears and couplings are eliminated.

It is easier to remove the motor from the roller than to take off a pinion. Another aid to speed up maintenance.

FOR ROLLER CONVEYORS. Roller conveyors handling tubing and bars can be kept moving more steadily with the simplified Floating-motor Drive. The jobs of installation and maintenance are made easier. Misalignment is no longer a problem.

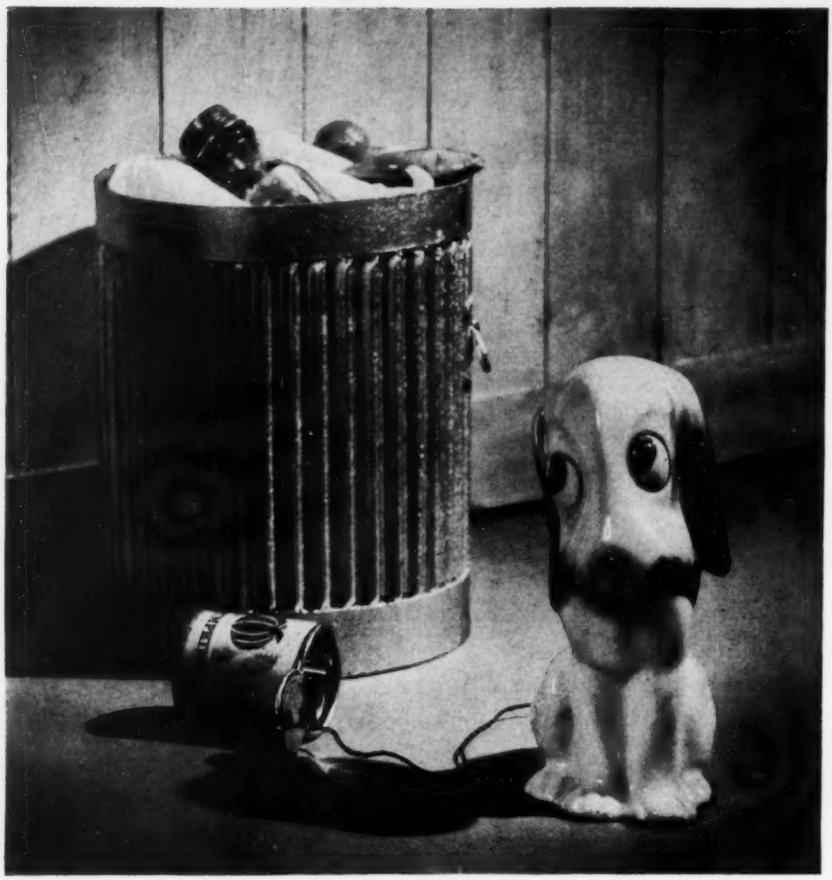


RELIANCE ELECTRIC & ENGINEERING COMPANY

1088 IVANHOE ROAD CLEVELAND, OHIO

RELIANCE A-C D-C MOTORS

Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Greenville (S. C.), Houston (Tex.), Los Angeles, Minneapolis, New York, Philadelphia, Pittsburgh, Portland (Ore.), St. Louis, San Francisco, Syracuse (N. Y.), and other principal cities.

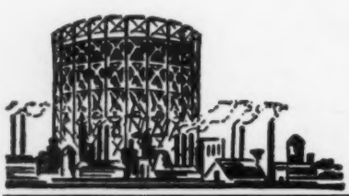


A Dog's Life!

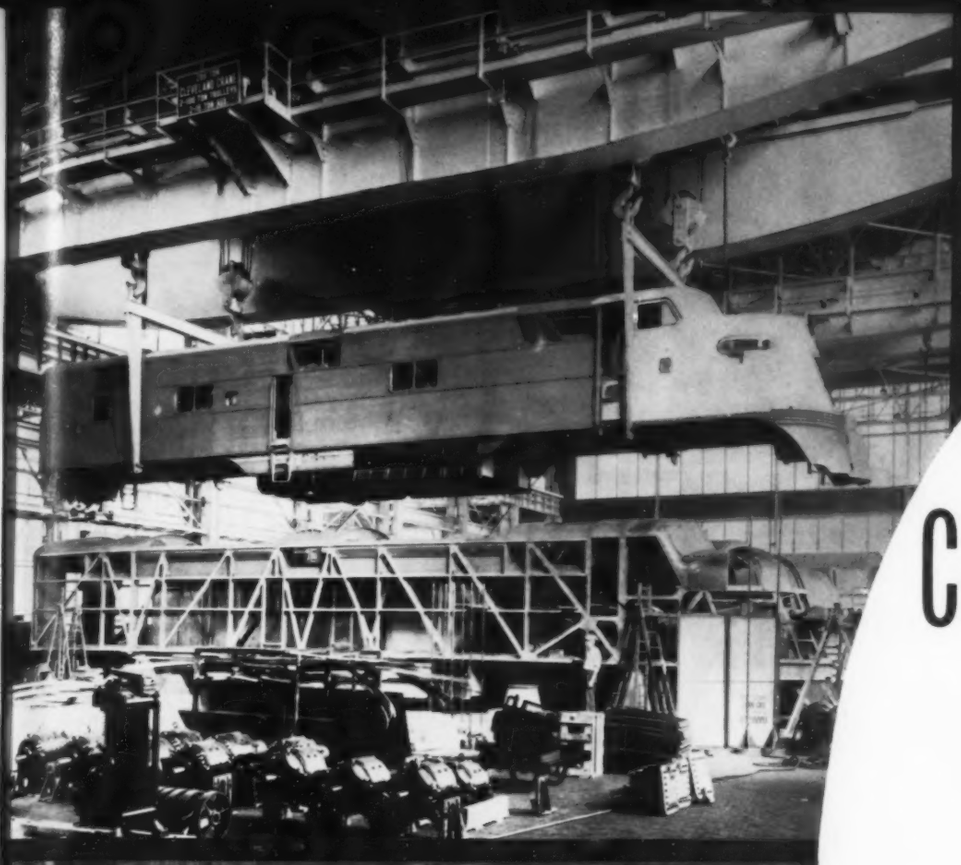
YOUR job these days may make a dog's life seem downright attractive. But getting production *at a profit* is a lot easier in some plants than others.

That's why the great majority of America's newest steel mills, the leading producers in the automotive, non-ferrous, textile, ceramics and food industries today employ the Industrial Carburetor.

Fuel savings of 15 to 40 per cent are the rule wherever Kemp equipment goes to work. Let us outline for you the scope of Kemp services and suggest what you may expect of Kemp in your job. Address **The C. M. Kemp Manufacturing Company, 405 East Oliver St., Baltimore, Md.**



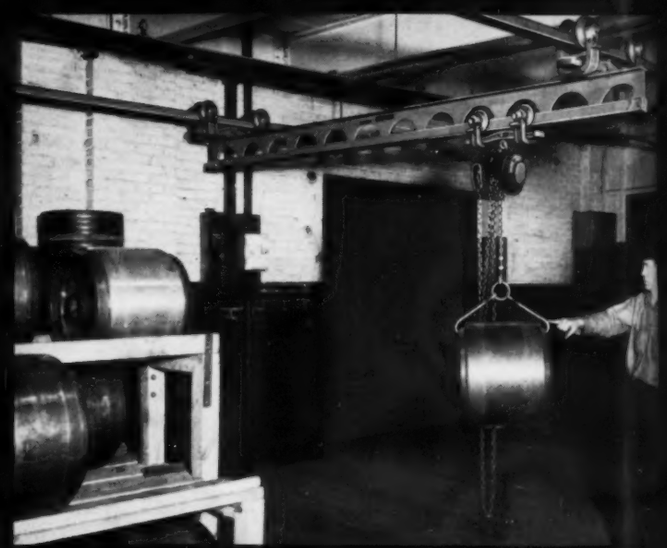
KEMP of BALTIMORE



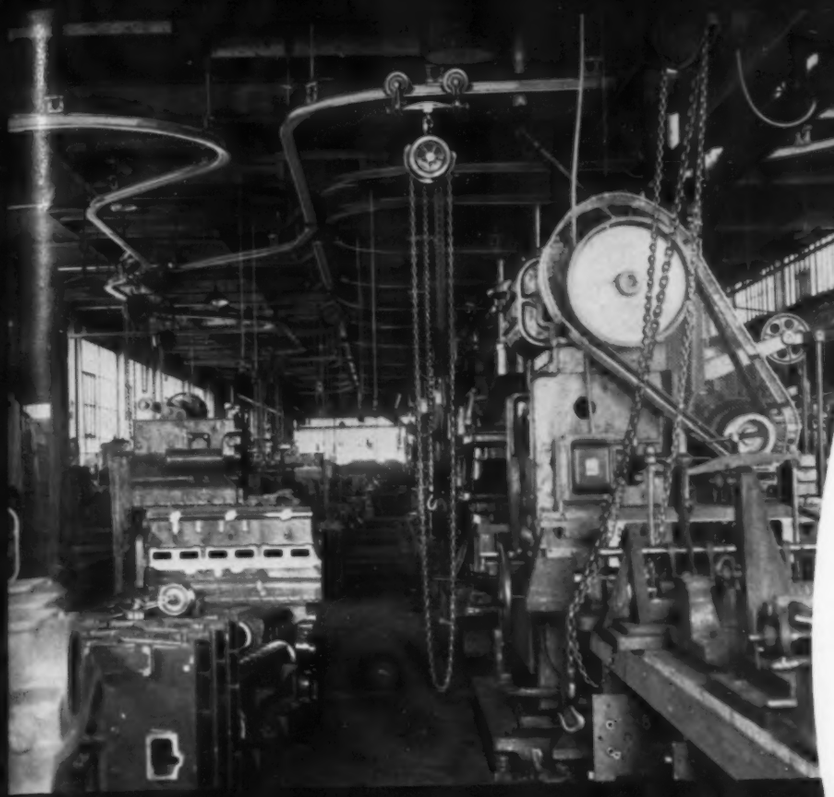
CLEVELAND CRANES

ALL-WELDED OVERHEAD TRAVELING CRANES

THE CLEVELAND CRANE & ENGINEERING CO.
WICKLIFFE, OHIO



THE CLEVELAND CRANE & ENGINEERING CO.
WICKLIFFE, OHIO.

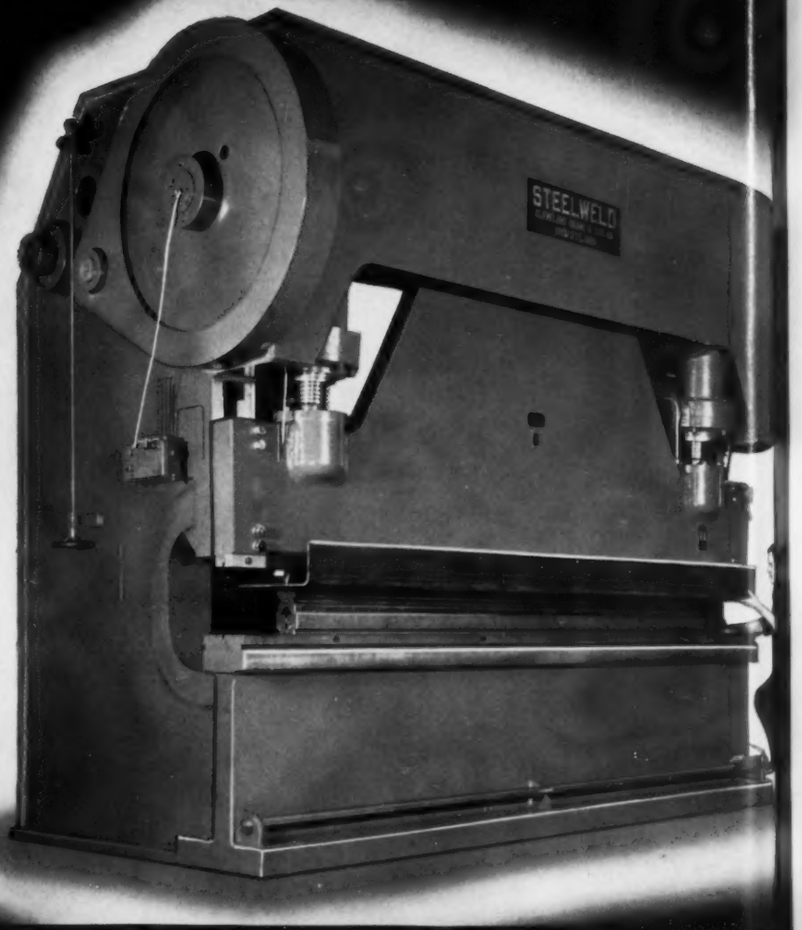


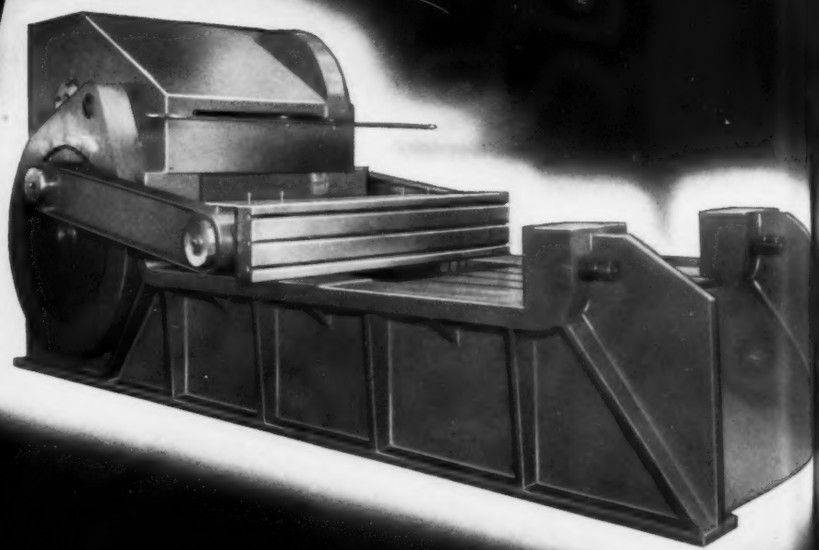
CLEVELAND TRAMRAIL

OVERHEAD MATERIALS HANDLING EQUIPMENT

STEELWELD MACHINERY

BENDING PRESSES
BULLDOZERS
SPECIAL MACHINERY



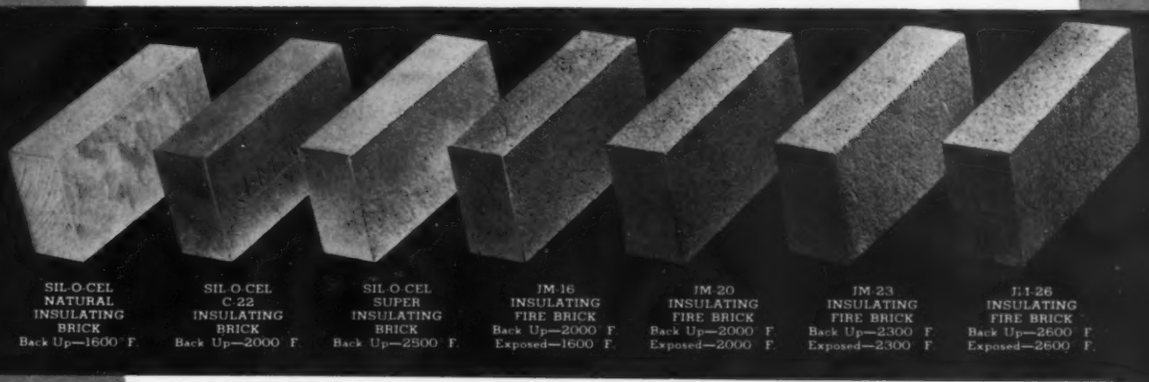


THE CLEVELAND CRANE & ENGINEERING CO.

WICKLIFFE, OHIO.

DO YOU HAVE THE FACTS ON THIS COMPLETE LINE

of J-M Insulating Brick and Insulating Fire Brick?



SIL-O-CEL NATURAL INSULATING BRICK Back Up—1600° F.

SIL-O-CEL C-22 INSULATING BRICK Back Up—2000° F.

SIL-O-CEL SUPER INSULATING BRICK Back Up—2500° F.

J-M 16 INSULATING FIRE BRICK Back Up—2000° F. Exposed—1600° F.

J-M 20 INSULATING FIRE BRICK Back Up—2000° F. Exposed—2000° F.

J-M 23 INSULATING FIRE BRICK Back Up—2300° F. Exposed—2300° F.

J-M 26 INSULATING FIRE BRICK Back Up—2600° F. Exposed—2600° F.

NOW, with the recent addition of three *new* brick, the J-M Line includes seven insulating brick and insulating fire brick—each designed for a specific temperature and service. Like all J-M Insulating Materials, they can be relied upon for dependable performance under severe operating conditions.

For a complete description of the properties and characteristics of these seven Johns-Manville Brick, ask for folder IN-91A. Johns-Manville, 22 E. 40th Street, New York, N. Y.

Service Recommendations for J-M Brick

Here is a partial list of the many types of furnaces and equipment where the seven Johns-Manville Brick shown on this page are recommended for use as insulating fire brick or as insulating brick behind a refractory lining:

Annealing Furnaces
Bake Ovens
Bustle Pipes
Carburizing Furnaces
Case Hardening Furnaces
Drawing Furnaces
Electric Furnaces
Flues
Forge Furnaces
Gas Producers
Galvanizing and Tinning Furnaces
Hardening Furnaces
Hot Blast Mains
Hot Blast Stoves
Heat Treating Furnaces
Incinerators
Japanning Ovens
Normalizing Furnaces
Open Hearth Furnaces
Oil Heaters and Stills
Producer Gas Mains
Recuperators
Regenerators
Retorts
Radiant Tube Annealing Covers
Soaking Pits
Stress Relieving Furnaces
Stacks
Salt Bath Furnaces

All J-M Insulating Brick and Insulating Fire Brick furnished accurately sized in standard 9" shapes of the 2½" and 3" series, and in special sizes.

JM PRODUCT

Johns-Manville INDUSTRIAL INSULATIONS

For every temperature . . . for every service

INDEX TO ADVERTISERS

A

Aetna-Standard Engineering Company..... 47
Alliance Machine Company.....188
Allis-Chalmers Manufacturing Company.....174–175
American Air Filter Company.....130
American Hammered Piston Ring Division
of Koppers Company.....181–182–183
Amsler-Morton Company..... 4
Askania Regulator Company.....138
Automatic Transportation Company.....179–180

B

Bailey Meter Company..... 46
Baker-Raulang Company.....200
Bartlett-Hayward Division of Koppers Company...181–182–183
Bloom Engineering Company.....128
Blaw-Knox Company..... 36
Bonnot Company.....125
Broden Construction Company..... 23
Edgar E. Brosius Company, Inc.....186
Burt Manufacturing Company.....198

C

Calgon, Inc.....191
Carbone Corporation.....202
Clark Controller Company.....159–160
Cleveland Crane and Engineering Company.....17–18–19–20
Cleveland Electric Illuminating Company.....178
Continental Roll and Steel Foundry Company..... 38
Colt's Patent Fire Arms Manufacturing Company.....163
Crocker-Wheeler Electric Manufacturing Company.....48–49
Crouse-Hinds Company.....139
Cutler-Hammer, Inc.....Cover 2

D

DeLaval Steam Turbine Company.....114–142
Delta Star Electric Company..... 32
Joseph Dixon Crucible Company.....194
John C. Dolph Company.....149

E

Electric Controller and Manufacturing Company.....6–7
Electric Service Supplies Company.....126
Electric Storage Battery Company..... 27
Electro Dynamic Works, Electric Boat Company.....199
Elwell-Parker Electric Company.....145
Engineering and Construction Division
of Koppers Company.....181–182–183

F

Farrel-Birmingham Company, Inc.....196
Farval Corporation..... 3
Flinn and Dreffein Company..... 23

G

Gas and Coke Division of Koppers Company.....181–182–183
Gatke Corporation.....190
General Electric Company.....34–35–127–Cover 4

H

Hagan Corporation.....164
Hallden Machine Company..... 23
Hays Corporation.....141
Holophane Company, Inc.....156
Hyatt Bearings Division, General Motors Sales Corporation...169

I

I-T-E Circuit Breaker Company.....Cover 3

J

Johns-Manville..... 21
W. A. Jones Foundry and Machine Company.....173

K

Kane and Roach, Inc..... 50
C. M. Kemp Manufacturing Company..... 16
Koppers Coal Company.....181–182–183
Koppers Company.....181–182–183
Koppers-Rheolaveur Company.....181–182–183

L

Leeds and Northrup Company..... 26
Lewis Foundry and Machine Division, Blaw-Knox Company.... 36
Lincoln Engineering Company.....172
Linde Air Products Company.....44–45
Link-Belt Company.....165
Lintern Corporation.....154

M

Mackintosh-Hemphill Company.....133
Maryland Drydock Company.....181–182–183
Mathews Conveyor Company..... 2
McKay Machine Company..... 23
Merco Nordstrom Valve Company.....194
Mesta Machine Company.....10–11
Morgan Construction Company.....197
Morgan Engineering Company..... 52
Morganite Brush Company, Inc..... 42

N

National Carbon Company, Inc., Carbon Sales Division.....168
National-Erie Corporation.....167
New York and New Jersey Lubricant Company.....198
Norma-Hoffmann Bearings Corporation.....177
North American Manufacturing Company..... 39

O

Ohio Electric Manufacturing Company.....195
Ohio Steel Foundry Company..... 43
Okonite Company.....161–162
Open Hearth Combustion Company.....157

P

Paramount Products Company.....144
Pennsylvania Transformer Company.....166
Penola, Inc.....185
Pittsburgh Lectromelt Furnace Corporation.....202
Poole Foundry and Machine Company.....134
Post-Glover Electric Company.....129
Pyle-National Company..... 1

R

Railway and Industrial Engineering Company.....189
Ready-Power Company..... 33
Reliance Electric and Engineering Company.....14–15
Republic Flow Meters Company.....176
Rockbestos Products Corporation..... 81
Rollway Bearing Company, Inc.....171
Ross Operating Valve Company.....143
Rowan Controller Company.....195
Joseph T. Ryerson and Son, Inc.....132

S

Schloemann Engineering Corporation..... 5
SKF Industries, Inc.....8–9
Socony-Vacuum Oil Company, Inc.....50–51
Streine Tool and Manufacturing Company.....40–41
B. F. Sturtevant Company.....28–29
Surface Combustion Corporation.....12–13
Swindell-Dressler Corporation.....146

T

Tar and Chemical Division of Koppers Company...181–182–183
Tide Water Associated Oil Company..... 37
Timken Roller Bearing Company.....Cover 1
Tool Steel Gear and Pinion Company.....201
Trufio Fan Company.....140
Trumbull Electric Manufacturing Company.....131

U

Union Carbide and Carbon Corporation.....44–45–168
United Engineering and Foundry Company.....152–153–203

V

Vaughn Machinery Company.....150–151

W

Wagner Electric Corporation.....147–155–158
Wean Engineering Company, Inc..... 23
Wean Engineering Company of Canada, Ltd..... 23
Wellman Smith Owens Engineering Corporation, Ltd..... 23
Western Gas Division of Koppers Company.....181–182–183
Westinghouse Electric and Manufacturing Company.....192–193
White Tar Company of New Jersey, Inc.....181–182–183
Wood Preserving Corporation.....181–182–183
R. D. Wood Company.....170
Worthington Pump and Machinery Corporation.....187

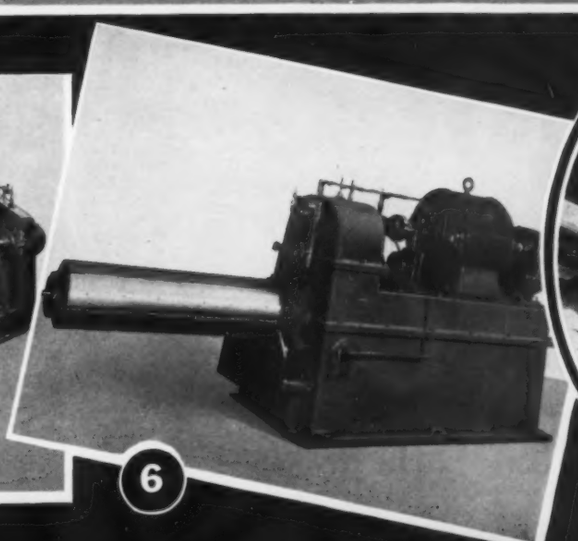
Y

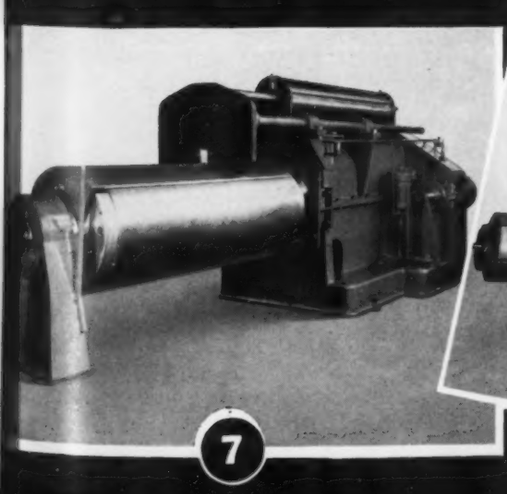
Yale and Towne Manufacturing Company.....24–25

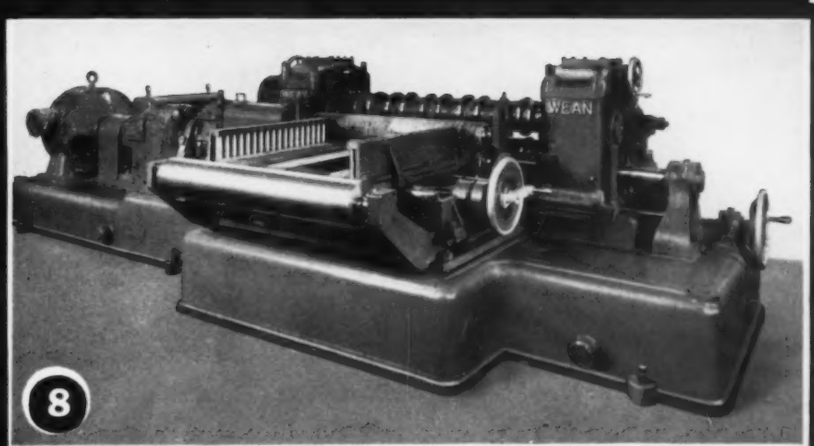
WEAN

WEAN EQUIPMENT for opening "PRODUCTION BOTTLENECKS"

1. Wean Tin Plate Shearing Line
2. Wilson Annealing Furnace
3. Heavy Duty Leveller
4. Hydraulic Stretcher Leveller
5. Wean Strip Shearing Line
6. Wean Reel (Expanding Type)
7. Wean Reel (Tension Type)
8. Slitter or Side Trimmer (Combination Type)







The WEAN ENGINEERING Company, Inc.

WARREN, OHIO

ASSOCIATED COMPANIES

E WILSON ENGINEERING COMPANY
Cleveland, Ohio

E McKAY MACHINE COMPANY
Youngstown, Ohio

NN & DREFFEIN CO.
Chicago, Ill.

E WELLMAN SMITH OWENS ENGINEERING CORP., Ltd.
London, England

E HALLDEN MACHINE CO.
Thomaston, Conn.

E WEAN ENGINEERING CO. of Canada, Ltd.
Hamilton, Ontario

diary Company

E BRODEN CONSTRUCTION CO.
Cleveland, Ohio

facturers of
rip and Wire Mill Machinery

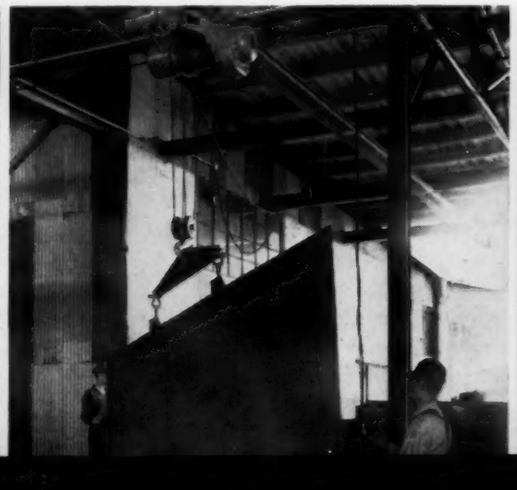
If you would like a free reproduction of this picture, suitable for framing, write to Yale & Towne Mfg. Co., Dept. R., Philadelphia, Pa.

November 4, 1776, saw one of the most important minutes in American History . . . Matthew Thornton of New Hampshire affixed his signature (the last) to The Declaration of Independence. Thus, by democratic processes and through their duly elected representatives the citizens of the new American Nation mutually pledged to protect for themselves and their posterity, the inalienable rights of mankind—life, liberty, and the pursuit of happiness.

On May 16, 1940, came another important minute . . . President Franklin Delano Roosevelt, in a special message to the assembled houses of Congress, asked for speedy approval of a program for defense to cost over a billion dollars, and recommended that an air force of 50,000 planes be prepared immediately—gave notice to the world that our 164-year-old Republic intended to remain a great Nation.

YALE Electric Telescopic-Lift Fork Truck tiering pallet loads of tin plate.

YALE Cable King Electric Hoist handling heavy steel sheet.



YALE Red Streak Hand Lift Truck cuts handling time for this company.

MINUTES...

DECIDE THE FATE OF AMERICA

Thornton's action was the final touch to our heritage of freedom and democracy. President Roosevelt's action pledged that the principles of our forefathers would be upheld—that every American industry—every citizen would protect our great heritage.

However, all fateful minutes in American History are not dramatic. In today's emergency, business executives are making unheralded decisions that are every bit as fateful—are installing modern Yale Materials Handling Equipment to help them gain extra minutes of production time—keep materials in flow—prevent idle men and machines.

For nearly 75 years, it has been Yale's privilege to provide American industry with safe, efficient, dependable, production-speeding Materials Handling Equipment.

In today's crisis, there comes from our assembly lines a steadily increasing stream of Yale Equipment to enable America to forge her defense armor in the shortest possible time.

THE YALE & TOWNE MANUFACTURING COMPANY
PHILADELPHIA DIVISION

Philadelphia, Pa., U. S. A. YALE In Canada: St. Catharines, Ontario

SEE OUR EXHIBIT AT THE IRON AND STEEL EXPOSITION, BOOTHS 86, 87, 88, 89—CLEVELAND PUBLIC AUDITORIUM, CLEVELAND, OHIO SEPT. 23-25 INCLUSIVE

YALE Electric Fork Truck transports skids of steel stampings quickly.

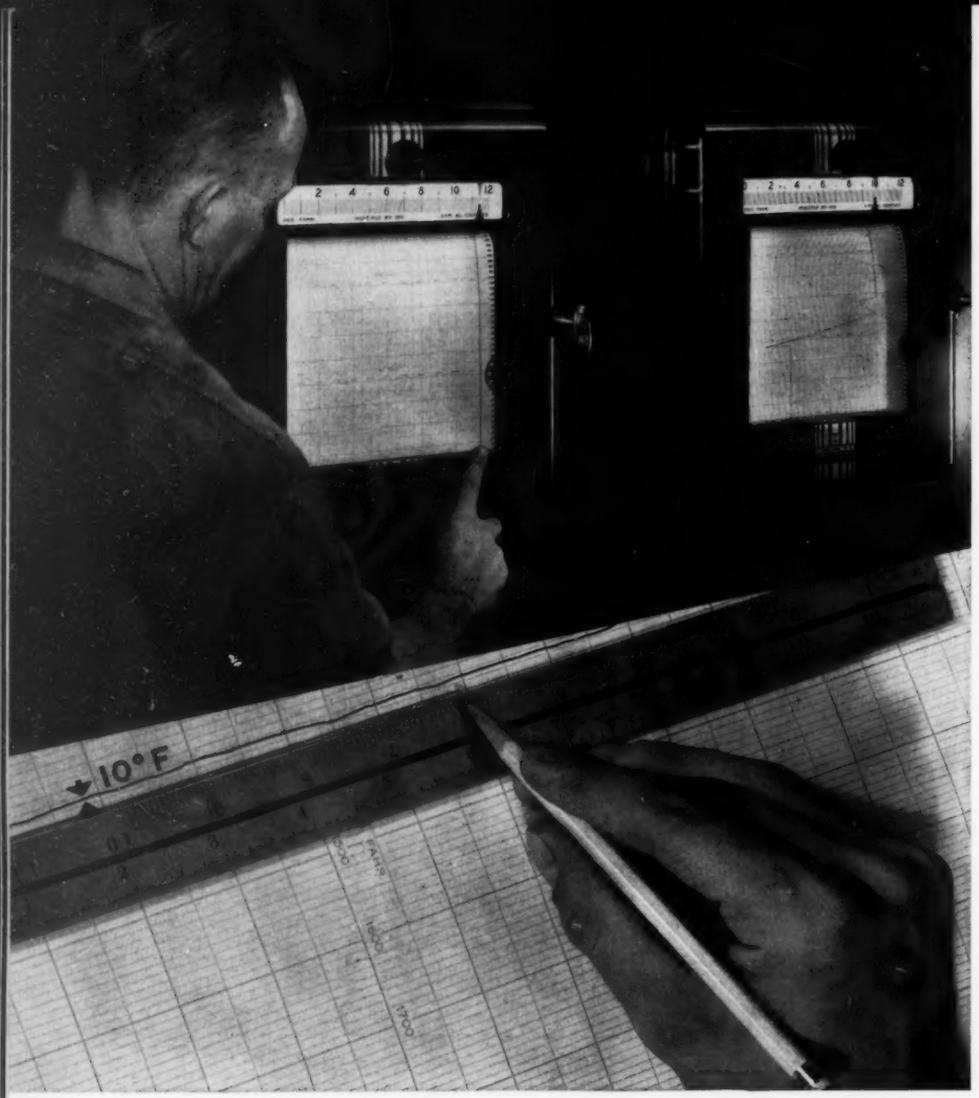
YALE Cable King Electric Hoist handles bulky loads easily.

YALE Ball Bearing Spur-Geared Hoists take steel sheets from rollers.

YALE Hand Lift Pallet Truck moves heavy pallet loads swiftly.

YALE Electric Fork Truck loads quickly, steel sheets in freight cars.

YALE Ball Bearing Spur-Geared Hoist speeds loading of steel sheets in motor truck.



"STRAIGHT-EDGE" CHARTS Are Hard To Get From MICROMAX Pyrometers

If you want pyrometer records to look as if they were drawn with a straight-edge, you may have trouble getting them from Micromax Controlling Pyrometers. For these instruments are "micro-responsive" in recording as well as in controlling —they not only *correct* the tiny temperature changes, but they *record* them. They put down the complete situation honestly and accurately, for the information of all concerned.

But, just as you'll find the tiny changes—the "wiggles"—shown in abundance, so you'll find practically no big changes in the record of any well-made, well-run furnace. And the reason, again, is the responsiveness of the Controller. The responsiveness which enables the instrument to correct the weaker upsets also makes it go after the stronger ones with correspondingly greater energy, and stop them before they become big enough to do more than jog the Controller. Temperature is thus held with the *steadiness* vital to uniform quality of product.

For further information about Micromax Control, write for literature.

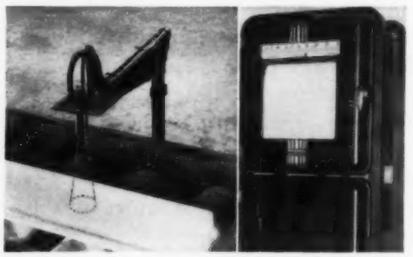
Recorder For Furnace Current

To help in operating big inductance-type and arc-type electric furnaces, several companies have added Micromax load recorders to the control panel. Note ease with which operator can see details of load record.

The recorder is almost identical with a thermocouple instrument, but requires even less maintenance. If interested, write for Catalog N-58-161.

Red-Face Corner

We strive, in preparing advertising messages, to under-state rather than over-state, but we hope never again to carry this policy so far as we recently did, in a bit we wrote about a Speedomax recorder.



Measuring the temperatures of steel strip, sheet, etc., as it flew through rolling mills has long been the principal metallurgical work for Speedomax Pyrometers. To it has been added such work as recording the rate of cooling during the quenching of steel parts.

This machine, we said, is used in a metallurgical research lab, and records the temperature of steel during the quench which is part of heat-treatment. So far, so good; that's what this particular Speedomax does.

But, we also said that the machine records temperature even when the latter is plunging downward at 70 degrees per second—and that turns out to be pretty ridiculous. It's true that this particular cooling-rate is 70 per sec., but Speedomax could keep up if it were 700. So we're sorry; if you're more interested now than before, we'll be glad to send further information.

Jrl Ad ENT-0600C(29)

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

Use the Exide System

...and simplify your battery maintenance

MAINTENANCE MEN are free for other work when Exide-Ironclad Batteries are installed.

The Exide System makes battery maintenance simple and brief:

1. **You ordinarily flush an Exide-Ironclad about once every two weeks.**
2. **Wiping each battery down occasionally, or blowing it off with an air hose, keeps it clean.**
3. **You charge with the Exide Charge Control Unit, which charges the battery at exactly the right rate, then shuts off the current automatically and flashes a signal light to show that the battery is ready for service.**

More facts about this easy maintenance method appear in the booklet, "The Exide System for Better Material Handling." Write for your free copy today.

THE ELECTRIC STORAGE BATTERY CO., Philadelphia
The World's Largest Manufacturers of Storage Batteries for Every Purpose
Exide Batteries of Canada, Limited, Toronto

A Mighty Air Battle

fought in boiler rooms

BEYOND THE WHIRR of every airplane propeller there is the whirr of a generator. Before there can be any staccato bark of machine guns, there first must be the rat-a-tat-tat of riveters in power plant construction. Back of the whistle of every shell there must be a factory whistle — and the hum of industry.

Today war is a war of machinery. And the best defense against the roar of war is the roar of power.

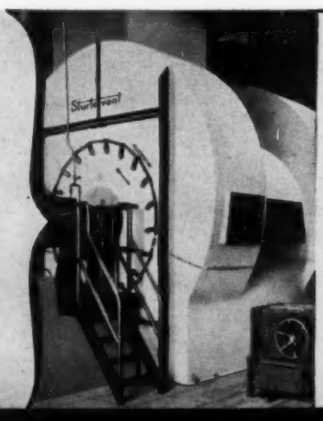
That is why in preparing for the task ahead, America has placed her power plants in the very front lines of Defense.

And that is why a mighty air battle is being fought in boiler rooms — in the boiler rooms of central stations and manufacturers' power plants, where giant Sturtevant mechanical draft units fan the flames of power and squeeze the last atom of energy from every pound of coal.

Of existing steam plants, producing a total of over 37,000,000 KW, a large percentage is Sturtevant equipped. Of the 13,600,000 KW generating capacity now under construction or proposed — a large percentage will be served by Sturtevant.

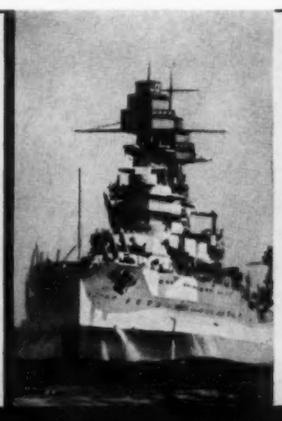
A majority of American warships afloat, or under construction, is equipped with Sturtevant mechanical draft apparatus or other form of air handling equipment.

Sturtevant
REG. U. S. PAT. OFF.
Puts Air to Work
in Power Production



Mechanical Draft Fans

This typical Sturtevant Mechanical Draft Installation is in Station A, largest plant of Pacific Gas and Electric System, San Francisco, California.



Navy Forced Draft

Sturtevant Forced Draft Fans fulfill severe Navy specifications. They are installed on a majority of United States battleships, cruisers, destroyers and other vessels.

And, on another front — in courageous, war-torn England — a total of almost 900 mechanical draft fans of Sturtevant design are doing thumbs-up duty in 66 power stations!

B. F. STURTEVANT COMPANY

Hyde Park, Boston, Mass. *Branches in 40 Cities*

B. F. Sturtevant Company of Canada, Ltd., Galt, Toronto, Montreal

Sturtevant

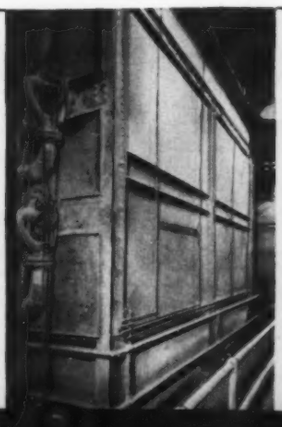
REG. U. S. PAT. OFF

Puts Air to Work

STURTEVANT — FOUNDER OF THE AIR HANDLING INDUSTRY

Air Heaters

Save fuel by utilizing flue gases to heat combustion air.



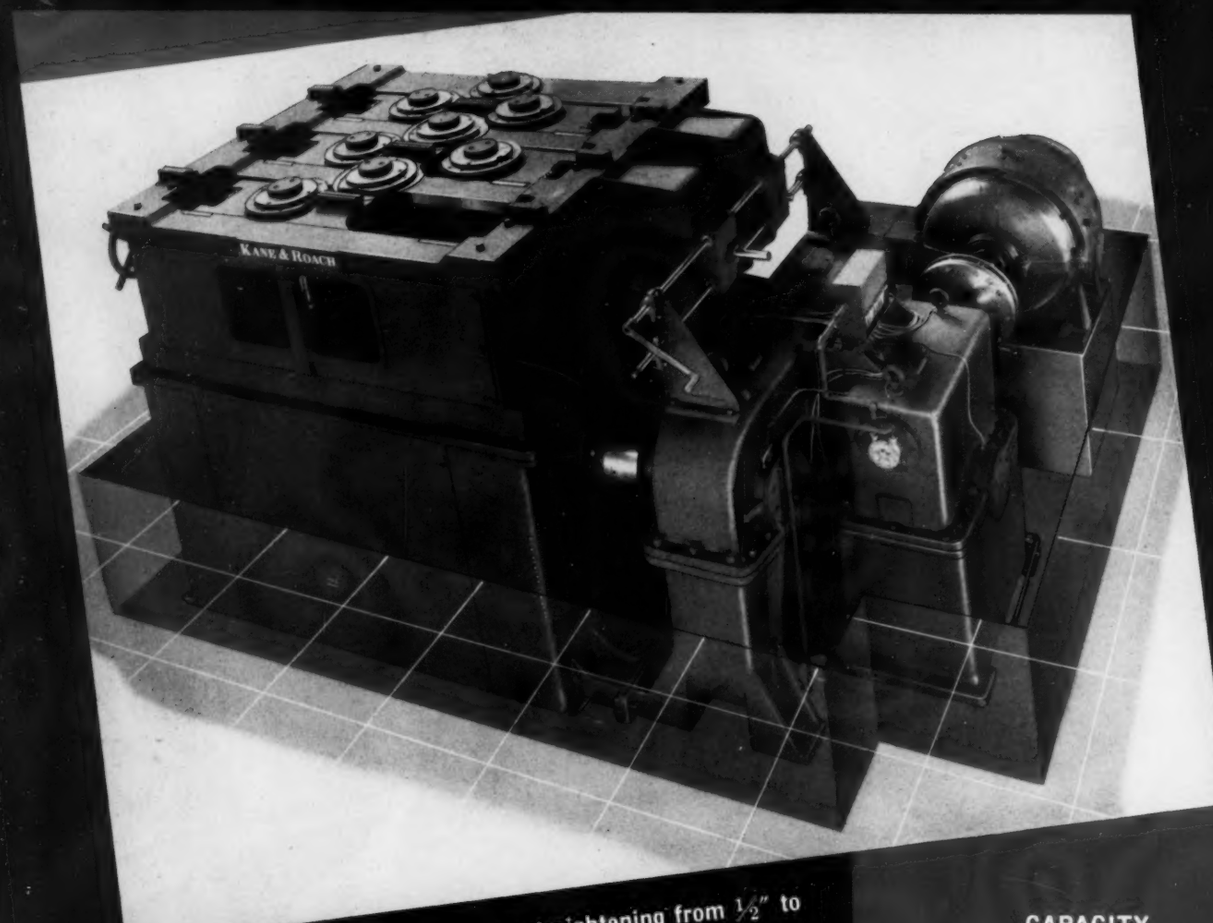
Fuel Economizers

Save fuel—so vital to defense—by utilizing waste flue gases to heat boiler feed water.

Flue Dust Control

Today, when uninterrupted operation of power equipment is vitally essential, Sturtevant Flue Dust Collectors are playing a particularly important role. Even more important than controlling flue dust discharge is reduction of fan wheel erosion—cutting down "outage" for replacement or repairs.

K&R 9VS VERTICAL SHAFT TWO PASS STRAIGHTENING MACHINE



This machine is built in several sizes for straightening from ½" to 4" heat treated square bars and proportionate shapes.

CAPACITY

Heat Treated Steel 130,000 lbs. Tensile Strength

12 x 2 Flat on Flat

8 x 1 Flat on Edge

4 x 4 Square

These machines are employed for straightening tool steel and alloy bar stock where the production does not justify the use of a Combination Vertical and Horizontal Straightener, and they are also used for large bar and billet sections to substantially reduce the cost of straightening, as compared to bulldozer or gag press operations.

Manufacturers of:

Cold Roll Forming Machines, Straightening Rolls, Bending Rolls, Gang Slitters, Edging Machines, Crimping Machines, etc.

KANE & ROACH

INCORPORATED

Syracuse, New York

Established 1887